Curriculum for B Tech/ Dual Degree and Int. MSc Academic Programs

NATIONAL INSTITUTE OF TECHNOLOGY, ROURKELA

Vision of Institute:
To become an internationally acclaimed institution of higher learning that will serve as a source of knowledge and expertise for society and be a preferred destination for undergraduate and graduate studies.

Mission of Institute:
To advance and spread knowledge in the area of Science & Technology leading to creation of wealth and welfare of humanity.

Guiding Principle

* Build an environment that is conducive to academic pursuit, nurturing creative thoughts and inculcating a spirit of inquiry.

* Promote free exchange of knowledge and experience with others, while respecting each other’s right to intellectual property.

* Ensure quality, speed, economy and transparency in all spheres of our activities.

* Create a truly multicultural community and promote cultural bonding and teamwork among all.

* Provide opportunity to every member of the Institute for achieving academic excellence, developing all round personality and realizing his or her full potential.

* Adopt state of the art technology in all endeavors.

* Serve the society around, using the knowledge and expertise of the Institute.

### COMMON COURSES FOR FOUR YEAR AND FIVE YEAR ACADEMIC PROGRAMME
FIRST SEMESTER (STRUCTURE COMMON TO ALL BRANCHES)

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Details course Syllabus

**CE 1500 Environment And Safety Engineering 3 Credits [3-0-0]**

**Environmental Engineering:**
Introduction to Environmental engineering Nature and scope of environment problems; Ecosystem; Local, regional and global environmental challenges, Basic concepts of biodiversity and its significance.

Water Pollution: Fundamentals and Control Strategies: Water quality-physical, chemical & biological characteristics, Drinking water standards; Effluent quality requirements; Water and wastewater treatment processes-treatment train, physical, chemical and biological unit operations.
Air Pollution: Fundamentals and Control Strategies; Air pollution - sources, classifications and regulations; and their effects, Monitoring Principles and instrumentation for particulate and gaseous pollutant measurements; Air pollution control strategies: physical, chemical and biological methods.

Noise standards and criteria, Noise pollution measurement in ambient air and industrial complex, Control methods for noise pollution; Engineering principles in waste management, Case studies on industrial applications of cleaner technologies in industries.

Environment Management and Sustainability Tools for sustainable management including ISO certification, environment audit, EIA;

**Safety Engineering:**

Workplace Accidents and Safety: Accident Causation Theories ( Domino Theory, Human Factor Theory), Accident Investigation and Reporting. Legal Aspects of Safety: Factories Act 1948, Other International Codes (OSHA Laws & Regulations).


**Essential Reading:**

**Supplementary Reading:**
Statics: Introduction: Basic Concepts of Force, Moment and Couple; Equilibrium of Coplanar force systems; Friction, Belt friction and Screw Jack; Internal forces in Members of Trusses and (Method of joints, Method of Sections) and Analysis of Frames (Method of Members); Properties of Surfaces: Centroid and Moment of Inertia of plane figures, Principle of Virtual Work and application;


Essential Reading:

Supplementary Reading:

**CS 1000 Basic Programming & Data Structure 2 Credits [1-0-2]**

Introduction: Basics of a computer, Introduction to C, Language evolution (Machine, Assembly, High-level), Assembler, Compiler, Interpreter, Problem solving and Algorithm, structure of a C program;
C Fundamentals: Character set, Identifiers and Keywords, Data Types, Constants and Variables, Declarations, Expressions, Statements, Symbolic constants;
Input and Output: Library functions for data input and output
Decision Statements: if, if-else, nested if-else, if-else-if ladder, break and continue, goto, switch case.
Loop Control: for, nested for, while, do-while
Array: Declaration, Initialization, 1-D array and Operations (Searching, Sorting), 2-D array and Operations, Multi-Dimensional arrays, String array declaration and initialization, String standard functions and operations;
Pointers: Address and Pointer, Pointer Declaration, Pointer Arithmetic, Pointers to Arrays, Array of Pointers, Pointers to Pointers, Pointers and Strings;
Functions: Function Declaration and Definition, Parameter Passing Mechanisms, Passing Array to a Function, Nested Functions, Recursion;
Storage Classes: Scope and Lifetime of an identifier, Automatic Variables, External Variables, Static Variables, Static External Variables, Register Variables;
Structure and Union: Declaration and Initialization of Structures, Structure within Structure, Array of Structures, Pointer to Structure, Passing Structure to Functions, typedef, Bit Fields, Enumerated Data Type, Union;
Files: File Streams, Opening a File, File I/O, Closing a File, Command Line Arguments, Write/Read Structures from/to Files.

Reference Books:

EE 1000 Basic Electrical Engineering 3 Credits [3-0-0]

Introduction:
Sources of energy, steam, hydro and nuclear power generation, general structure of electrical power systems.

DC Networks:
Kirchhoff’s laws, node voltage and mesh current methods, delta-star and star-delta conversions, superposition principle, Thevenin’s and Norton’s theorems, Maximum Power Transfer Theorem.

Single phase AC circuits:
Single phase emf generation, average and effective values of sinusoids, solution of R, L, C series circuits, j operators, solution of parallel and series-parallel circuits, series -parallel resonance.

Three-phase AC circuits:
Three phase emf generation, delta and star connections, line and phase quantities, solution of the three phase circuits with balanced voltage and balanced load conditions, phasor diagram, measurement of power in three phase circuits, three phase four wire circuits.
**Magnetic circuits:**
Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits.

**DC machine:**
Construction, emf and torque equations, speed control of DC motors.

**Single Phase Transformer:**
Construction, emf equation, phasor diagrams at no load and full load, equivalent circuit, regulation and efficiency.

**Induction Motor:**
Introduction to three-phase induction motor, construction, principle of rotating magnetic field, starting; single phase induction motor, principle of operation.

**Measuring Instruments:**
Introduction to basic instruments, voltmeter, ammeter and wattmeter, principle of analog and digital measurements.

Essential Reading:

Supplementary Reading:

**EC 1000 Basic Electronics Engineering 3 Credits [3-0-0]**

**Module-I: (Analog Electronics) 10 Hrs**
Part-1: Introduction to electronic Systems; Part-2: Diode circuit models and Applications: - Introduction to circuit models, Clippers and Clampers. Part-3: Transistors –BJT and MOSFET: - BJT construction and operation, BJT configurations, BJT current components BJT characteristics, Transistor as an amplifier and switch, MOSFET.

**Module-II: (Digital Electronics Fundamentals) 10 Hrs**
Part-1: Brief on Digital Electronics: - Review of logic gates, Number systems;
Part-2: Combinational Circuits: - Combinational logic (4 variables K-map), Flip flops (T, D, JK), Counters and Registers;
Part-3: Data Converters: - Digital-to-Analog Converter (DAC), Analog-to-Digital Converter (ADC).
Module-III (Special Topic in Electronics) 16 Hrs
Part-2: Linear operations using Op-amp:- Inverting amplifier, Non-inverting Amplifier, Voltage follower, Summing and Difference amplifier, Integrator and Differentiator, Comparator;
Part-3: Miscellaneous Electronic Devices:- SCR, LED, Photodiode, Laser, Solar Cells, Opto-Couplers.;
Part-5: Introduction to basic Communication systems/principles: Fundamentals of Analog communication (AM, FM), Introduction to digital communication (Sampling, PAM,PCM,PPM,PWM, Modulation and demodulation techniques ), Communication Networks, Introduction to Mobile Communication (Lecture notes to be provided)

Text Book (Essential Reading):
1. Microelectronic Circuits, Oxford University Press, S. Sedra and K. C. Smith; Sixth edition
3. Digital Fundamentals, Floyd, Pearson Education India; 10 edition

Reference:

WS 1151 Workshop Practice 2 Credits [0-0-3]

Carpentry and Fitting Shop
Carpentry Practice; Use of hand tools for holding drilling, cutting, marking and mixed tools such as vice, clamps, saw, hammers, mallet, screwdriver, etc.; Different carpenter joints and their application (Mortish and Tanon, Dovetail, Half Lap) etc.
Importance of fitting operation such as chipping, sawing, filling, scraping, drilling, reaming etc; Functions, classification of tools, work holding and clamping specific tools for example File (length, type, grade of cut etc.) vices, cold chiesel, hand tools etc.; Fitting Practice and Jobs: Male-Female Joint; Chipping; Filling; Scraping; Marking; Fitting.

Machine Shop
Introduction to metal cutting; Machine Tools; Different types of machining operations: Straight turning; step turning; taper turning; thread cutting; milling; drilling; CNC machining
Welding and Foundry Shop
Understanding of difference between gas welding and arc welding; difference between welding and soldering; Introduction to gas welding; Use of welding equipment and tools and accessories including Personal Protective requirement such as Boot, Gloves, safety goggles, Apron, etc.; Welding Practice: Butt Joint; T – Joint; Introduction to brazing process, filler material and fluxes; application of brazing.
Introduction to pattern; casting process; mould making; Practice on different types of mould making

Electrical Electronics and Computer Shop
Soldering and Desoldering Practice; To Make Halfwave and Full Wave Rectifier Circuit and Analyze The Wave Form By Using A Cathode Ray Oscilloscope; To Make An Electrical Wiring Connection of A Flourescent Lamp; To Make An Electrical Wiring For Controlling Two Lamps From A Switch Board; To Make An Electrical Wiring For Controlling Different Loads From A Switch Board; To Make Electrical Connection For Controlling A Lamp From Two Positions And From Multiple Positions.

Carpentry and Fitting Shop
Carpentry Practice; Use of hand tools for holding drilling, cutting, marking and mixed tools such as vice, clamps, saw, hammers, mallet, screwdriver, etc.; Different carpenter joints and their application (Mortish and Tanon, Dovetail, Half Lap) etc.
Importance of fitting operation such as chipping, sawing, filling, scraping, drilling, reaming etc; Functions, classification of tools, work holding and clamping specific tools for example File (length, type, grade of cut etc.) vices, cold chiesel, hand tools etc.; Fitting Practice and Jobs: Male-Female Joint; Chipping; Filling; Scraping; Marking; Fitting.

Machine Shop
Introduction to metal cutting; Machine Tools; Different types of machining operations: Straight turning; step turning; taper turning; thread cutting; milling; drilling; CNC machining

Welding and Foundry Shop
Understanding of difference between gas welding and arc welding; difference between welding and soldering; Introduction to gas welding; Use of welding equipment and tools and accessories including Personal Protective requirement such as Boot, Gloves, safety goggles, Apron, etc.; Welding Practice: Butt Joint; T – Joint; Introduction to brazing process, filler material and fluxes; application of brazing.
Introduction to pattern; casting process; mould making; Practice on different types of mould making
Electrical Electronics and Computer Shop
Soldering and Desoldering Practice; To Make Halfwave and Full Wave Rectifier Circuit and Analyze The Wave Form By Using A Cathode Ray Oscilloscope; To Make An Electrical Wiring Connection of A Flourescent Lamp; To Make An Electrical Wiring For Controlling Two Lamps From A Switch Board; To Make An Electrical Wiring For Controlling Different Loads From A Switch Board; To Make Electrical Connection For Controlling A Lamp From Two Positions And From Multiple Positions.

Essential Reading:

Supplementary Reading:
1. Workshop: Practice Chapman

CY 1101 CHEMISTRY 3 Credits [2-1-0]

PHYSICAL CHEMISTRY:

Spectroscopy: Interaction of molecules with electromagnetic radiation, rotational, vibrational and electronic spectroscopy, selection rules, basic concepts of emission, absorption and LASER.

Chemical kinetics: Rate equation, order, molecularity, methods of determination of order of a reaction, examples and rate equations of zero, first, second and pseudo first order reactions, temperature dependence of rate constants, Arrhenius theory, concept of activation energy, significance of catalysts.

Electrochemistry: Oxidation-reduction reactions, electrochemical cells, Nernst equation and its significance, standard reduction potential, calculation of solubility product, mean ionic activity coefficient and pH of aqueous medium, commercial dry cell batteries (alkaline) and hydrogen fuel cells (basic idea).

INORGANIC CHEMISTRY:

Atomic, molecular chemistry: Schrodinger wave equation (origin of quantization), Interpretation of wave function (radial and angular), Hydrogen atom: concept of atomic and molecular orbitals, Structure, bonding and energy levels of diatomic molecules. Examples N₂, O₂, CO and HF. Chemical bonding: VB, VSEPR, MO theory, Werner’s coordination theory, Chelate Effect (Metal-EDTA complexes), Crystal field theory: splitting of tetrahedral and octahedral complexes, structural concepts of Ni(CO)₄, Fe(CO)₅ and Mo(CO)₆ complexes, Importance of metal ions in biological systems (Mg, Fe & Cu).

Organic reaction mechanisms & reactive intermediates: Introduction to Organic compounds, Reactions of aliphatic compounds, Carbocations, carbanions and free radicals
(Generation, stability and reactions), substitution ($S_N1$, $S_N2$, $S_Ni$, neighbouring group participation, factor affecting SN reaction), elimination (E1, E2, E1CB) and addition reactions (C-C double bond).

General methods of polymerisation, common types of polymers and their application in daily life.

**Essential Reading:**


**Supplementary Reading:**


**CY 1170 CHEMISTRY LABORATORY 2 Credits [0-0-3]**

Determination of Hardness of water, Determination of the amount of Dissolved oxygen in water sample, Estimation of Iron content in the given Iron salt solution, Estimation of Calcium in given lime stone sample, Reaction kinetics of Hydrolysis of Ester, Kinematic viscosity of Oil by Redwood Viscometer, Determination of Optical rotation of Sucrose, Partition coefficient of a binary mixture, Conductometric titration of strong acid vs strong base, Potentiometric titration of weak base vs strong acid.

**HS 1300 Communicative English 2 Credits [2-0-0]**

**Course Contents:**

1. Language and Communication: Nature of human language, Misconceptions about language, General introduction to English language
2. Sign, Image, Symbols and Text: Word formation, Foreign words, Loan words, Varieties of English
3. Remedial Grammar: Parts of Speech, Subject-Verb-Agreement, Punctuation, Frequent errors; Practical Evaluation
Sensitivity, Working and Communicating in Teams, Business English, Case Studies
5. Writing: Emails, Letters, Reports, Documents/Memo, Paragraph writing, Practical Evaluation
6. Neologisms, Political Correctness, Vocabulary Building Exercises, English Idioms and idiomatic expressions

Course Outcome:
The course will help the learners acquire the necessary skills essential for successfully communicating both in personal and professional situations, along with improving their general English knowledge that can assist them towards achieving their goal of effectively communicating in English.

Essential Readings

Suggested Readings:

HS 1270 Language Lab 2 Credits [0-0-2]
The Digital Language Lab provides resources and facilities for language instruction and learning. It is an interactive, software based, multimedia learning system that is used for imparting effective language learning skills, with the potential for learning independently at required pace and convenience.

Course Contents:
1. Conversation Practice, Vocabulary Building and Role Playing
2. Improve advanced reading and writing skills: Increase ability to negotiate through texts of a complex or technical nature. Summarization /forming a gist, writing argumentative and narrative essays and paragraphs,
3. Group Discussions
4. Oral Presentations on contemporary topics – prepared and extempore
5. Business communication games and activities
6. Group Projects

LS 1001 Biology 2 Credits [2-0-0]

**Essential Reading**


**Supplementary Reading**


**MA 1001 DIFFERENTIAL, INTEGRAL AND VECTOR CALCULUS (Math I) 4 credits [3-1-0]**

**Differential Calculus:** Real number system, Completeness axiom, Sequence (monotone, bounded and Cauchy sequences), Limits, Continuity and Differentiability of functions, Rolle’s Theorem, Mean value theorems, Series of real numbers, Tests for convergence of Series, Taylor’s and Maclaurin’s theorems with remainders, Indeterminate forms. **Functions of several variables**-Partial Differentiation, Total Differentiation, and Change of variables – Jacobians, Maxima and minima of functions of two and three variables – Lagrange’s method of Multipliers.

**Integral Calculus:** Riemann integration, Introduction to improper integrals, Beta and Gamma integrals, Differentiation under integral sign; Double and triple integrals.

**Vector Calculus:** Scalar and Vector fields, Vector differentiation, Gradient of scalar field, Directional derivative, Divergence and Curl of a vector field, Laplacian operator. Vector integration- Line, surface and volume integrals, Green’s theorem in plane, Gauss divergence theorem, Stokes’ theorem.

**Essential Readings:**

Matrix Theory:
Gauss elimination method, Gauss-Jordon method for finding inverse of a matrix, Vector space, subspace, linear span, linear dependence and independence, Basis and dimension of vector space, Row and column spaces, Rank and nullity of a matrix, Rank and Nullity Theorem, Inner product spaces, Gram-Schmidt Orthogonalization, Matrix representation of Linear Transformations, Solvability of systems of linear equations, Eigen values, Eigen vectors, Diagonalization of matrices, Reduction of a quadratic form to canonical form.

Ordinary differential equations of first order:
Geometrical interpretations, Separable equations, Reduction to separable form, Exact equations, Integrating factors, Linear equations, Bernoulli equations, orthogonal trajectories, Existence and uniqueness of IVP (Picard’s Theorem), Applications to physical problems.

Ordinary linear differential equations of higher order:
Fundamental system and general solutions of homogeneous equations of order two, Wronskian, reduction of order, Solution of non-homogeneous equations by method of undetermined coefficients and variation of parameters. Extension to higher order differential equations, Euler-Cauchy equation, Power series method, Applications to physical problems.

Laplace Transform:
Laplace and inverse Laplace transforms, existence of Laplace transform, first shifting theorem, transforms of derivative and integral, second shifting theorem, differentiation and integration of transforms, Convolution theorem, Solution of ordinary differential equations with constant coefficients.

Essential Reading:

Suggested Readings:
4. Kawk And Hong, Linear Algebra
5. N. Piskunuv, Differential and Integral Calculus
Galilean relativity and Galilean transformation, Special relativity, Michelson Morley experiment and postulates of relativity, length contraction and time dilatation, twin paradox, Doppler effect, Lorentz transformation & velocity addition, relativistic momentum, mass-energy relation, brief introduction to general relativity.

**Quantum Mechanics:**
INADEQUACIES IN CLASSICAL PHYSICS: Black body radiation, photoelectric effect, X-ray diffraction, Compton Effect, pair production, photon and gravity, Davisson-Germer experiment
WAVE-PARTICLE DUALITY: Particle nature of wave, Wave nature of particle, de Broglie waves, group waves, phase velocity & group velocity, uncertainty principle and its application.
WAVE FUNCTION: probability & wave equation, linearity and superposition of wave of wave functions, expectation values SCHRÖDINGER EQUATION: time dependent and time independent Schrödinger equation, eigenvalue & eigenfunctions, boundary conditions on wave function, APPLICATION OF SCHRÖDINGER EQUATION: Particle in a box, Finite potential Well.

**Essential Reading:**

**Supplementary Reading:**

**PH 1002 Physics-II 3 Credits [2-1-0]**

**Statistical Mechanics:** Statistical distributions, Maxwell-Boltzmann statistics, molecular energies in ideal gas, quantum statistics: B-E & F-D statistics, Rayleigh-Jeans formula, Planck's radiation law, specific heats of solids, free electrons in metals, electron-energy distribution,

**Solid State Physics:** Crystalline and amorphous solids, crystal structure, point defect, dislocations, ionic crystals, covalent crystals, van der Waals bond, metallic bond, band theory of solids, classification of solids based on band theory, Impurity semiconductors, semiconductor devices (Junction diode, tunnel diode) photodiode: LED, semiconducting LASER and solar cell. Introduction to superconductivity, Meissner effect, Type I and type II superconductors, Bound electron pair (elements of BCS Theory) and high temperature superconductors.

**Particle Physics:** Fundamental interactions, Leptons, Hadrons, Gluons, Elementary Particle quantum numbers, conservation laws.

**Essential Reading:**

**Supplementary Reading:**


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**DEPARTMENT OF BIOTECHNOLOGY AND MEDICAL ENGINEERING**

**Curriculum of B.Tech (Biomedical Engineering)(BM)**

**Vision:**
To become a globally recognized department of higher learning by producing quality engineers and technologists in the field of Biomedical Engineering.

**Mission:**
To advance and spread knowledge in the area of Biomedical Engineering through multidisciplinary teaching and research contributing to healthcare, food, energy and environment.

**Program Educational Objectives:**

i. To understand and apply the concepts of Engineering and Sciences including Biology in Medicine that will build career and pursue higher studies in Biomedical Engineering.

ii. To identify, analyze and solve the problems with novelty and updated knowledge in the development of product/process/technique related to healthcare to meet the societal demands.

iii. To make graduates proficient in written and oral communications in their professions and to impart value added continuing education for sustained growth.

iv. To apply the acquired practical skills and training for effective teaching, research, development and entrepreneurship in biomedical field.

**Program Outcome:**

i. Graduates will be fundamentally strong in solving mathematical, engineering, scientific problems related to healthcare.

ii. Graduates will be able to identify, formulate and analyze complex problems related to biomedical and their solutions using principles of mathematics, science and engineering.

iii. Graduates will be able to design and develop biomedical devices that meet the desired specifications for industrial and medical applications.

iv. Graduates will be able to use research based knowledge and research methods including design of experiments, analysis and interpretation of data to provide valid conclusions.

v. Graduates will be able to develop, select and apply feasible techniques, resources and software tools with an understanding of the limitations in biomedical applications.

vi. Graduates will be able to apply contextual knowledge to assess societal, health and safety related issues relevant to biomedical field.

vii. Graduates will be able to dispose professional, ethical and societal responsibility.

viii. Graduates will be able to recognize the need for health issues, and engage themselves in life-long learning in the broadest context of technological changes in biomedical field.

ix. Graduates will be able to function effectively as an individual, entrepreneur and as a member or a leader in multi-disciplinary streams including tissue engineering, biomaterials, biomechanics, medical equipments and instrumentation.

x. Graduates will be able to effectively communicate with the society, make reports, design documents and presentations.
Graduates will be able to participate and succeed in competitive examinations like GATE, NET, Civil services, etc.

**Process for defining the Vision and Mission of the Department and PEO of the program:**

i. Discussion and feedback of experts from academy and industry

ii. Brainstorming session conducted by the department internally with department faculty members, students and faculty from other departments in relevant areas.

iii. Following other institutes and universities website.

### THIRD SEMESTER

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Not offers Minor Degree.

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### DEPARTMENT OF BIOTECHNOLOGY AND MEDICAL ENGINEERING

**Curriculum of B.Tech (Biotechnology)(BT)**

**Vision:**
To become a globally recognized department of higher learning by producing quality engineers and technologists in the field of Biotechnology.

**Mission:**
To advance and spread knowledge in the area of Biotechnology through multidisciplinary teaching and research contributing to healthcare, food, energy and environment.

**Program Educational Objectives:**

1. To understand and apply the concepts of Biology, Chemical Engineering and related aspects of science and technology to build career and pursue higher studies in Biotechnology
2. To identify, analyze and solve problems with novelty and updated knowledge in the development of product/process/technique to meet the societal demands and to impart value added continuing education for sustained growth.
3. To demonstrate professional and ethical attitude with awareness of current issues and think about the social entailment of their work, especially its impact on safety, health and environment
4. To apply acquired practical skills and broad biotechnological training to excel in service to industry, R&D and entrepreneurship.

**Program Outcome:**
i. Graduates will be able to plan, act and perform in consonance with set of career goals and objectives in Biotechnology.

ii. Graduates will be able to apply the fundamentals of basic sciences and different engineering principles in biotechnology to solve complex problems related to healthcare, food, energy and environment.

iii. Graduates will be able to effectively communicate with industry and solve live industrial problems.

iv. Graduates will be able to design and develop processes, products and plants of industrial importance.

v. Graduates will be able to assimilate knowledge across disciplines and to carry out interdisciplinary research in Biotechnology.

vi. Graduates will be able to dispose professional, ethical and societal responsibility.

vii. Graduates will be able to venture entrepreneurship in biotechnology and related fields.

viii. Graduates will be able to participate and succeed in competitive examinations like GATE, NET, Civil services, etc.

ix. Graduates will be able to cope up with the global standard of higher education and research.

x. Graduates will be inquisitive in understanding cutting edge areas of Biotechnology.

Process for defining the Vision and Mission of the Department and PEO of the program:

i. Discussion and feedback of experts from academy and industry

ii. Brainstorming session conducted by the department internally with department faculty members, students and faculty from other departments in relevant areas.

iii. Following other institutes and universities website.

### THIRD SEMESTER

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### DEPARTMENT OF CIVIL ENGINEERING

**Curriculum of B.Tech )Civil Engineering((CE)**

**Vision/Mission:**

To generate quality manpower, carry out innovative research and consultancy projects to design, build and maintain Civil Engineering Infrastructure ensuring environmental health and quality life.
Program Educational Objectives:

1. To provide the students with a comprehensive and balanced understanding of various disciplines of Civil Engineering in depth and breadth to create solutions for real life problems.
2. To provide students with sound knowledge of fundamentals with mathematical acumen for a clear understanding of Civil Engineering as a whole.
3. To provide opportunities to students to study associated subjects and work in interdisciplinary projects across allied branches of Engineering in order to impart ability to work in multidisciplinary teams.
4. To provide students with academic environment that is aware of excellence, leadership, entrepreneurship and ethical responsibility.

Program Outcome:

1. Graduates will be competent in all disciplines of Civil Engineering with a clear understanding of underlying principles of engineering.
2. Graduates will produce Civil Engineering designs based on strong fundamentals considering cost effectiveness and sustainability.
3. Graduates will relate Civil Engineering knowledge to field practice involving many allied subjects.
4. Graduates will be leaders in their profession as well as in other activities with highest ethical standards.

Process for defining the Vision and Mission of the Department and PEO of the program

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DEPARTMENT OF CHEMICAL ENGINEERING

Curriculum of B.Tech Chemical Engineering((CH))

Vision:
To become an internationally acclaimed department of higher learning to address major societal issues and solve technical challenges faced by chemical and allied industries through ecofriendly technologies.

Mission:
1. To inculcate students with a strong fundamental knowledge to meet the needs of a rapidly changing technological environment in process development and equipment design.
2. To carry out vibrant interdisciplinary research programme that can creatively shape the undergraduates and graduates to address the needs of chemical engineering profession in particular and society in general.
3. To develop leadership qualities to solve scientific and environmental challenges keeping in mind the safety and ethical concerns.

Program Educational Objectives:
1. To prepare students to achieve professional engineering competence.
2. To acquaint with the principles of basic science and engineering and utilize them to formulate, solve and analyze engineering problems as well as to prepare them for advanced studies both in core and multidisciplinary research area.
3. To take initiative and demonstrate ability towards independent learning and introduce professional ethics and codes of professional practices.
4. To function effectively in the complex modern work environment with the ability to assume professional leadership roles.
5. To develop effective communication skills.
Program Outcome:

i. Function effectively as an engineering professional, individual, and member or leader in diverse technical teams.
ii. Apply knowledge of mathematics, science and engineering to identify, formulate & solve engineering problems.
iii. Design and conduct experiments individually as well as in a team.
iv. Apply engineering techniques with modern engineering tools necessary for designing a system, component or process.
v. Demonstrate excellence in ethical standards, safety practices, and environmental protection.
vi. Effectively communicate through technical writings and presentations
vii. Develop interest in multidisciplinary research activity and higher studies and engage in life-long learning process.

Process for defining the Vision and Mission of the Department and PEO of the program:

i. Regular interaction with the stakeholders, more frequently with employers, alumni and other institutes of higher learning.
ii. Inclusion of courses based on industrial demand through course modification as suggested by industry experts.
iii. Modifying the course contents as per the directives of American Chemical Society (ACS); American Institute of Chemical Engineers (AIChE) and experts from institutes of higher learning and various research organizations.
iv. Feedback from the students.
v. Discussion in the senate of the institute.

THIRD SEMESTER

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**TABLE OF MINOR DEGREE COURSES**

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**DEPARTMENT OF CERAMIC ENGINEERING**

**Curriculum of B.Tech )Ceramic Engineering((CR)**
Vision:
To become nationally and internationally acclaimed center of higher learning and research in the field of ceramic and materials engineering that will serve as a source of knowledge and expertise for industry and academia and be a preferred destination for undergraduate, postgraduate students as well as research.

Mission:
• To produce highly qualified graduates possessing strong foundation in ceramic engineering worthy of serving industry, academia and research organization in India and abroad.
• To develop strong liaisons with industries and academia fostering multidisciplinary activities.
• To pursue fundamental and creative research in the science and engineering of novel ceramic materials and publish enduring scientific literature.

Program Educational Objectives:
a) To prepare graduates for successful careers in industry and research meeting the needs of industries, academia and research organizations.

b) To provide a strong foundation in mathematical, scientific and engineering fundamentals with an emphasis on the synthesis-structure-property-application relationship in ceramic materials.

c) To develop the ability among the graduates to comprehend, analyze, and solve industrial processes, product development problems through proper training relevant to the general practice of Ceramic Engineering.

d) To develop strong interaction with industries through collaborative research, student training, consultancy and to work on multidisciplinary and real life industrial problems.

e) To impart training in design and computational skills, and provide opportunity for specializing in specific areas of interest and broad knowledge in multi-disciplinary engineering subjects.

f) To develop strong communication skills, ability to work as an effective team member, and for providing an awareness of life-long learning.

Program Outcome:
Graduates shall have the ability

I. To apply the knowledge of mathematics, science, and engineering in ceramic industrial and research.

II. To design, conduct experiments, interpret and analyze data.

III. To design a system, component, or process for meeting the needs of ceramic and allied industries.

IV. To identify, formulate and solve engineering problems as leader/team member.

V. To use modern techniques, skills, and latest engineering tools in industrial and research problems.

VI. To communicate effectively, to appreciate the need of professional and ethical responsibility as well as life-long learning.

VII. To participate and succeed in competitive examinations like GATE, GRE, TOEFL.
Process for defining the Vision and Mission of the Department and PEO of the program:

1. Regular assessment of the student through class test, quiz and term paper.
2. Counseling of the students.
3. Use of multi-media teaching.
4. One to one interactions between faculties and students.
5. Industry and academia interaction on regular basis.
6. Industry collaboration research work.

### THIRD SEMESTER

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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

Curriculum of B.Tech )Computer Science & Engineering((CS)

Vision:
The vision of the department is to prepare its students for professional employment and graduate education through study and implementation of the fundamental principles of theory, abstraction, and software design, while at the same time presenting the ethical and social issues associated with computer science

Program Educational Objectives:
I. To establish a fruitful engineering career in industry, government, or academia and contribute in the socio-economic growth of the nation by developing innovative ideas, and translating them into commercial products and services that benefit the society.

II. To function effectively as a team member and/or leader in multidisciplinary and multicultural environments, to promote entrepreneurial skills and to practice their profession with high regard to legal and ethical responsibilities.
III. To pursue lifelong learning through such activities as higher studies, distance education, professional training and membership in professional societies and to be able to adapt to new engineering tools and technologies.

Program Outcome:
I. To provide necessary background in basic engineering for pursuing studies in Computer Science and Engineering.
II. To provide a strong background on theoretical computer science.
III. To develop the ability among the students to analyse and solve real world engineering problems using computer technology.
IV. To impart knowledge on hardware technology to the undergraduate students to have an insight of the computer.
V. To impart knowledge to the students on high speed communication network, networking technology and security related issues.
VI. To equip the students with adequate technologies and theoretical background of software development that will help them to pursue a career in software industries.
VII. To provide experience to the students with advances in computer science and engineering through two semester project work & learning from experts time to time through interactions.
VIII. To educate students to stick on professional ethics and to solve societal needs.

Process for defining the Vision and Mission of the Department and PEO of the program:
I. It is in the line of Institute’s Mission and Vision with special emphasis to implementation of advanced and emerging techniques in various streams of Computer Science and Engineering. In fact, emphasis is being given for proper dissemination of Vision and Mission to stakeholders considering recent developments and better mechanisms.
II. Keeping the needs of the society in mind and the need of the industry, the process of establishment is given below
III. Industry-department based interactions at various levels on regular basis,
IV. Induction of courses based on industrial needs and modification in curricula.
V. Induction of courses based on recent developments being studied globally.
VI. Formulation and implementation of projects for government agencies, Public sectors Units (PSUs) and Industries.
VII. Capacity building by organising short term courses, workshops, conferences and training programs at various levels.
VIII. Providing training to the students in Industry or industry based projects.
IX. Regular evaluation and revision by Curriculum Advisory Committee
X. Interaction with alumni and incorporating their suggestions
XI. Encouraging novel ideas by support and funding through Entrepreneurship cell.

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**TABLE OF MINOR DEGREE COURSES**
DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

Curriculum of B.Tech (Electronics & Communication Engineering) (EC)

Vision:
To be globally recognized as a seat of learning and innovation in Electronics for application to Communication, Transportation, Defence, Industry, Health Care, Entertainment, and many other consumer products.

Mission:
1) To produce quality engineers in the field of Electronics and related domains.

2) To conduct research and develop products in the fields of Chip design, Communication Systems, Electronics Instrumentation, Signal Processing and other related areas with strong emphasis on critical state of the art applications.

3) To grow in the area of Design and Manufacturing of chips, boards and systems.

Program Educational Objectives:

<table>
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<tr>
<th>I.</th>
<th>To equip graduates for a successful career in electronic industry that meets the national and International needs.</th>
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<td>II.</td>
<td>To develop the ability among graduates to synthesis data and technical concepts for application to electronic product design and in solving real life problems in the industry.</td>
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<td>III.</td>
<td>To equip skills to graduate engineers to work as part of a multidisciplinary project.</td>
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<tr>
<td>IV.</td>
<td>To Provide sound foundation in mathematical scientific and engineering fundamentals necessary to formulate, solve and analyse complex engineering problems and prepare for graduate studies.</td>
</tr>
<tr>
<td>V.</td>
<td>To promote awareness of lifelong learning and introduce professional ethics and codes of professional practices.</td>
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<tr>
<td>VI.</td>
<td>To prepare graduates for taking of higher studies in electronics, communication engineering, management and related areas.</td>
</tr>
<tr>
<td>VII.</td>
<td>Promoting educational support-unities for ethnic minority, mature and alternatively qualified students and traditionally qualified students.</td>
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<tr>
<td>VIII.</td>
<td>To equip graduates for a successful career in electronic industry that meets the national and International needs.</td>
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Program Outcome:

<table>
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<th>a.</th>
<th>To gain necessary background in fundamental engineering concepts to pursue undergraduate studies in Electronics and Communication Engineering.</th>
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<td>b.</td>
<td>Learn Electronics system design so to be part of ever growing electronics industry.</td>
</tr>
<tr>
<td>c.</td>
<td>Acquire through knowledge in Tele-communication, Wireless communication systems, data communication techniques, satellite communication which form the backbone of current communication technology for a sustainable development.</td>
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<tr>
<td>d.</td>
<td>Learn to use digital signal processing, embedded systems and VLSI techniques for different engineering applications.</td>
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<td>e.</td>
<td>Develop the ability to analyze and solve real world engineering problems related to electronics and communication systems.</td>
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<tr>
<td>f.</td>
<td>Gain adequate technical and theoretical background on programing techniques pursue career in software industries.</td>
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<td>g.</td>
<td>Design and implement complex systems as a part of Research Project over two semesters.</td>
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<td>h.</td>
<td>Gain broad knowledge in multi-disciplinary subjects and domain knowledge to be a part of growing group of managers for industry through higher education studies leading to MBA</td>
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<tr>
<td>i.</td>
<td>Gain ability to understand patents, write term papers on advanced techniques in the field of Electronics and Communication Engineering.</td>
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Process for defining the Vision and Mission of the Department and PEO of the program:

A. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

B. **Problem analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

C. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

D. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

E. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

F. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

G. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

H. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

I. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

J. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
K. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

L. **Life-long learning**: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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### DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

**Curriculum of B.Tech )Electronics & Instrumentation Engineering((EI))**

**Vision:**

To be globally recognized as a seat of learning and innovation in Electronics for application to Communication, Transportation, Defence, Industry, Health Care, Entertainment, and many other consumer products.

**Mission:**
1). To produce quality engineers in the field of Electronics and related domains.

2) To conduct research and develop products in the fields of Chip design, Communication Systems, Electronics Instrumentation, Signal Processing and other related areas with strong emphasis on critical state of the art applications.

3) To grow in the area of Design and Manufacturing of chips, boards and systems.

Program Educational Objectives:

| I. | To provide students a successful career in industry that meets the needs of national and multinational companies. |
| II. | To develop the ability among students to synthesize data and technical concepts for application to electronic product design and to solve real life problems in industries. |
| III. | To provide opportunity for students to work as part of teams on multi-disciplinary projects. |
| IV. | To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze engineering problems and to prepare them for graduate studies. |
| V. | To promote students awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice. |

Program Outcome:

| To provide necessary background in basic engineering for pursuing studies in Electronics and Instrumentation Engineering |
| To acquire the knowledge on general measurement systems used in various fields in industries and laboratories including medical area and different sample testing laboratories |
| To provide the knowledge on computer based control system, PLC and virtual instrumentation system. |
| To develop the ability among the students to analyze and solve real world engineering problems using instrumentation technology. |
| To impart knowledge on hardware technology to the undergraduate students to have an insight of the computer. |
| To equip the students with adequate technologies and theoretical background of software development that will help them to pursue a career in software industries. |
| To provide experience to the students with advances in Electronics and Instrumentation Engineering through two semester project work & learning from experts time to time through interactions. |
| To develop the knowledge about the different sensors and data acquisition system for acquiring the data in real time environment and its proper analysis for characterization. |
| To provide a broad knowledge in multi-disciplinary engineering subjects and latest technological advancements in computing and applied domains of engineering. |

Process for defining Vision and Mission of the Department and PEO of the program:

A. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.

B. Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
C. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

D. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

E. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

F. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

G. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

H. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

I. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

J. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

K. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

L. **Life-long learning:** Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

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**TABLE OF MINOR DEGREE COURSES**

DEPARTMENT OF ELECTRICAL ENGINEERING

Curriculum of B.Tech (Electrical Engineering)(EE)
**Vision:**
It is the gospel truth that each entity in the world hopes to excel and with such aspiration the Department of Electrical Engineering has also set goalpost to achieve. It is aimed at becoming a promising player in imparting the relevant technical knowledge and to be elevated to the global status in excelling in research and innovation of high standard which will envy its neighbours. It sincerely plans to spread its credentials not confined to the country but across the globe knowing fully that it is a Herculean task.

**Mission:**
In pursuit of realizing the vision, the Department of Electrical Engineering has following strategies:

- The Department is dedicated to inculcate in the students the culture of independent thinking to unleash their potential to pursue high quality of research leading to innovation, the clarion call of the day.
- The Department is deeply committed to deliver the basic educational framework to create an academic environment of insatiable quest for learning in the temple of knowledge that will give birth to future leaders who will place the country in the pinnacle of success through their unfathomable determination for global reckoning.
- The Department has developed an atmosphere wherein the students have ample avenues to showcase their talents for creativity, fulfill their passion for extra-curricular activities, learn the nuisances for entrepreneurial skills and over and above able to crystallize their dreams to reality been guided by the faculty mentors and truly the domain has no bounds.

**Program Educational Objectives:**

- To prepare students for successful career in industry and academia those meet the objectives of Indian and Multinational organizations.
- To provide training to solve problems relevant to the general practice of Electrical Engineering and System Design and to impart state of the art technology in the areas of power, Drives, Control, Automation and Communication sectors leading to wealth and welfare of Humanity.
- To provide training to be experienced with the multifaceted aspects of using emerging software design and testing of electrical systems.
- To develop the ability among students to synthesize data and technical concepts for application to product design and development.
- To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze engineering problems and to prepare them for higher studies.
Program Outcome:
- Graduates will demonstrate knowledge of engineering mathematics, physics, chemistry, electrical and electronics engineering.
- Graduates will demonstrate an ability to identify, formulate and solve electrical engineering problems.
- Graduate will demonstrate an ability to design electrical and electronic circuits and conduct experiments with electrical systems, analyse and interpret data.
- Graduates will demonstrate an ability to design digital and analogue systems and component.
- Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
- Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyse problems.
- Graduates will demonstrate knowledge of professional and ethical responsibilities.
- Graduate will be able to communicate effectively in both verbal and written form.
- Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
- Graduate will develop confidence for self-education and ability for life-long learning.
- Graduate who can participate and succeed in competitive examinations like GATE, GRE.

Process for defining the Vision and Mission of the Department and PEO of the program:

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DEPARTMENT OF FOOD PROCESS ENGINEERING

Curriculum of B. Tech. (Food Process Engineering) (FP)

Vision:

To addresses the modern issues related to food processing and implement changes that incorporate cutting-edge research and technology to meet the challenges of today and the future food industry as well as to invigorate the program, and the profession at large, by redefining the practice of food process engineering for modern society. To addresses the modern issues related to food processing and implement changes that incorporate cutting-edge research and technology to meet the challenges of today and the future food industry.
as well as to invigorate the program, and the profession at large, by redefining the practice of food process engineering for modern society.

**Mission:**

I. To execute basic and applied research that advances the state of the profession.

II. To educate the next generation of academic and industry leaders, and preparation of students for successful careers in professional practice.

III. To contribute in selected services to institutions and government for assessing the technical resources and promoting solutions to meet significant societal problems related to food security, safety and processing.

**Program Educational Objectives:**

I. To develop knowledge and understanding about systems in the production, processing and consumption of food and an appreciation of their impact on society.

II. To impart knowledge about the nature of food and human nutrition and an appreciation of the importance of food to health.

III. To build up skills in researching, analyzing and communicating issues related to food preservation, processing, storage and packaging.

IV. To enhance skills in experimenting with and development of food products and equipment by applying theoretical concepts.

V. To develop skills in designing, implementing and evaluating solutions to food industry situations.

**Program Outcome:**

I. Students will develop ability to identify and discuss a range of historical and contemporary factors which influence the consumption of particular food product as well as accounts for individual and group food selection patterns in terms of physiological, psychological, social and economic factors.

II. Students will develop ability to explain and understand manufacturing processes and technologies used in the production of food products, examine the nature and extent of the food industry, justify processes of food product manufacturing and equipment design in terms of market, technological and environmental considerations.

III. Students will develop ability to evaluate the impact of the good manufacturing practices within the Indian food industry on the individual, society and environment.

IV. Students will develop ability to explain the role of nutrients in human health and develop, prepare and present food products using modern processing, preservation and packaging techniques.

V. Students will develop ability to evaluate the relationship between food production, consumption, promotion and health.

VI. Students will develop skills in regulating food product manufacturing process, storage, distribution, sale and import to ensure availability of safe and wholesome food for human consumption.

VII. Students will be able to provide scientific advice and technical support to food industry covered under Food Safety and Standards Authority of India, US FDA regulations and other related food standards.

**Process for defining the Vision and Mission of the Department and PEO of the program:**

I. The vision, mission and PEO of the program were defined based on the need of the society and food industry. Following parameters were considered.

II. The overall program should have the ability to apply knowledge of mathematics, science and engineering in food processing.
III. The program should train the students how to design a food product, system, component, or process to meet desired needs of food industry
IV. It should encourage the students to develop the ability to function in a team.
V. The program should develop characters of professional and ethical responsibilities.
VI. It should impart knowledge of contemporary issues of food processing and food safety.

### THIRD SEMESTER

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### DEPARTMENT OF FOOD PROCESS ENGINEERING

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DEPARTMENT OF INDUSTRIAL ENGINEERING

Curriculum of B.Tech. (Industrial Design)(ID)

Vision:
To create the next generation industrial designers and innovators who can provide innovative design solutions to the complex challenges faced by the industry and society.

Mission:
- To perform research and to provide contemporary education in the field of industrial design for creating useful and innovative products, systems and related services.
- To create innovative and thoughtful technologies with sufficient knowledge of art, culture and technology.
- To provide different sections of the society with creative entrepreneurs and leading industrial designers having a strong technological background with contemporary knowledge of manufacturing.

Program Educational Objectives:
To provide education and to develop leadership qualities required for industries by nurturing multiple skills.
To educate the students with engineering knowledge, innovation associated with designing and development of industrial products effectively.
To grow in the development of skills, knowledge and dispositions that enable graduates to immediately function as entry-level professional industrial designers.
To prepare graduates to design, develop, implement and improve integrated systems or products that include people, materials, information, equipment and energy using appropriate analytical, computational and experimental practices.
To nurture new thoughts, philosophies and research into several aspects of design/design related fields
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To nurture new thoughts, philosophies and research into several aspects of design/design related fields

Program Outcome:
- Design a component, system or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
- Independently develop design strategies, refine, detail and communicate design proposals.
- Interpret, represent and respond to the socio-economic and cultural contexts of industrial design and the ethical responsibilities of the professional designer.
- Resolve and communicate technical and manufacturing facets of industrial design projects using the conventions of the discipline.
- Contextualize, generate and apply aesthetic aspects of industrial design.
- Recognize and contribute to professional practice relevant to industrial design and develop an ability to engage in lifelong learning.
- Function in multidisciplinary teams and to communicate effectively.

Process for defining the Vision and Mission of the Department and PEO of the program:
- Conduction of interactive practical oriented lessons for each of the courses
- Incorporating course projects in most of the courses
- Dedicated industrial design projects in last 04 semesters
- Create a truly multicultural community and promote cultural bonding and teamwork among all.
- Conduction of short term courses / workshops on design oriented themes
- Industrial visits, collaborative industrial projects
- Students participation in sponsored design projects, patents, etc.

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DEPARTMENT OF MECHANICAL ENGINEERING

Curriculum of B.Tech (Mechanical Engineering) (ME)

Vision:
To provide the society and industry with Mechanical Engineers having superior technical capability and ethical responsibility.

Mission:
To nurture its students (B.Tech., M.Tech. and Ph.D.) with fundamentals of the subject and an up-to-date technological skill to meet regional as well as national priorities in higher education. The program also strives to enhance learning skill, quality research and scholarly activities to be integrated with teaching.

Program Educational Objectives:
I. The program provides excellent preparation for a career in mechanical engineering and prepares students for a career at the forefront of technology.
II. To train students in the methods of engineering science and in the application of these methods to conceive, organize and carry out the design of engineering systems.
III. To provide opportunity for students to work as part of teams on multidisciplinary projects.
IV. To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze engineering problems and to prepare them for higher studies.
V. To give students an experience with the multifaceted aspects of high end computers with latest software to solve real problems for design and analysis.
VI. To encourage students to develop an alternative carrier as an entrepreneur.
VII. To promote student awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.

Program Outcome:

- Function effectively as an Engineering professional as individual, and as a member or leader in diverse technical teams (term work, practical, mini project and project)
- Apply knowledge of mathematics, science, engineering fundamentals and core engineering subjects to define and apply them to solve Mechanical engineering problems
- Identify, formulate, study literature, and analyse broadly-defined engineering problems in reaching substantiated conclusions using analytical tools appropriate to respective discipline or area of specialization like Thermal, Design...
and Production engineering blended with interdisciplinary technologies (mini project, project, industrial visits, guest lectures, workshops).

- Select and apply appropriate techniques, resources, and modern engineering and IT tools (CNC machines, electrical discharge machines, electro chemical machines, optical microscopy, surface profilometer, data acquisition system, and softwares like Matlab, Ansys, Catia, Deform Solid Model etc.).
- Understand and commit to professional ethics and responsibilities and norms of engineering technology and practice (T&P, co-curricular activity)
- Nurture the graduates to become effective communicators [Communicate effectively on broadly-defined engineering activities with the engineering community and with society at large, by being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions] (Business communication, Project work, Mini project, Seminars, co-curricular activity, extracurricular activity)
- To provide suitable environment and motivation for research activity.

**Process for defining the Vision and Mission of the Department and PEO of the program:**

- Keeping the needs of the society in mind and the need of the industry
- Industry-department based interactions at various levels on regular basis,
- Induction of courses based on industrial needs and modification in curricula.
- Induction of courses based on recent developments being studied globally.
- Formulation and implementation of projects for government agencies, Public sectors Units (PSUs) and Industries.
- Capacity building by organising short term courses, workshops, conferences and training programs at various levels.
- Providing training to the students in Industry or industry based projects.

### THIRD SEMESTER

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DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Curriculum of B.Tech (Metallurgical & Materials Engineering)(MM)

**Vision:** We seek to develop in students, faculties, and staff of the department the ability and passion to work wisely, creatively, and effectively in the area of Metallurgical and Materials Engineering for the betterment of the nation in particular and mankind in general.

**Mission:** The mission of the Department is to advance the knowledge and educate students in areas of Metallurgical and Materials Engineering and technology to meet national requirements and challenges on academics, industrial and social fronts.

**Program Educational Objectives:**

I. To prepare students for successful careers in Indian/multi-national industries that meets all the necessary needs of a perfect professional as well as to excel in post graduate programs.

II. To make the students fundamentally strong in solving mathematical, engineering and scientific problems.

III. To train students with good scientific and engineering breadth so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.

IV. To indoctrinate the students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate engineering issues to broader social context.

V. To motivate students to develop ethics and codes of professional and social lives as well as to keep awareness of life-long learning.

**Program Outcomes:**

i. Graduates can demonstrate basic knowledge in metallurgical engineering and materials science.

ii. Graduates can reveal the ability to design and conduct experiments, interpret and analyses data, and generating correlation of obtained results.
Graduates can execute their aptitude to design a metallurgical process that meets desired specifications and requirements of industrial applications.

Graduates are able to visualize and work on laboratory and multidisciplinary tasks.

Graduates can demonstrate the ability to identify, formulate and solve metallurgical engineering problems.

Graduates can represent them in understanding their professional and ethical responsibilities.

Graduates are able to communicate effectively in both verbal and written forms. They are familiar with modern engineering software tools and equipment to analyses metallurgical engineering problems.

Graduates possess the confidence to apply engineering solutions in global and societal contexts.

Graduates are capable of self-education and understanding the value of lifelong learning.

Graduates are broadly educated and in understanding of the impact of metallurgical engineering on society and made capable to demonstrate awareness of its contemporary issues.

Graduates who can participate and succeed in competitive examinations like GATE, GRE, TOEFL.

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DEPARTMENT OF MINING ENGINEERING

Curriculum of B.Tech (MINING ENGINEERING)(MN)

Vision:
To become a global leader of higher learning in the field of eco-friendly exploitation and utilization of mineral resources for the welfare of the society and to be a preferred destination for undergraduate and graduate studies

Mission:
To carry out research and create human resource for developing and adopting appropriate technology towards sustainable development of mineral resources

Program Educational Objectives:
a) To provide necessary basic knowledge of science and engineering for pursuing studies in Mining Engineering
b) To provide a strong background on theoretical knowledge of Mining Engineering practices and advancements.
c) To develop the ability among the students to evaluate and analyze different practical aspects of mining and related activities.
d) To equip the students with the application of computer knowledge/software to solve mining problems.
e) To train the students to develop prototypes of mining methods, equipments, environmental and safety monitoring devices etc.

f) To provide a broad knowledge in multi-disciplinary engineering subjects in order to equip them to cope with the demand of industries other than mining

g) To develop among the students self learning and research ability through field experience and two semester project work to solve real life problems faced by the mining industry

**Program Outcome:**

I. To provide necessary fundamental and applied knowledge of science and engineering for a career in Mining and related Industries

II. To train the students to analyze problems, design, or develop models, conduct tests and experiments, evaluate information, and communicate results effectively

III. To enable the students to pursue advanced studies and other creative and innovative efforts in science, engineering, and technology, as well as other professional careers benefiting the society at large

IV. To understand, appreciate, and practice the issues of safety, hygiene, and sustainable environment

V. To imbibe the habit of performing to the highest standard of professional practice with ethics

**Process for defining the Vision and Mission of the Department and PEO of the program:**

Input is considered from multiple entities as academic experts from other institutions of higher learning both in India and abroad, leaders from industries, government regulatory and policy making agencies, alumni, students as well as parents.

**THIRD SEMESTER**

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### DEPARTMENT OF PLANNING AND ARCHITECTURE

#### Curriculum of B.ARCH (PA)

**Vision:**

To provide every citizen of India a proper habitat with appropriate facilities and services

**Mission:**

1. To provide socially responsible architects who would be leaders in the field of design, implementation, and management of human habitats and ancillary services, and also become experts in application of state-of-the-art technologies
2. To create planners for Contemporary India who are in tune with evolving socio-cultural, political, and techno-economic milieu and would be capable drivers of responsible development
3. To carry out original research that would contribute to the existing body of knowledge in architecture, planning, and allied disciplines.

**Program Educational Objectives:**

1. To impart understanding on the relationship between human, the built, and the natural environment, and heir evolution through time
2. To enable understanding and appreciation of experiential (visual, sensory, spatial) aspects, and to equip with skills for visualization and representation
3. To provide knowledge on the latest technological aspects of building sciences, including focus areas like illumination, acoustics, building services, building automation, etc.
4. To impart suitable design, technical, and managerial skills and know-how that are required to deal with user's requirements through proper investigation, identification of issues,

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1 This does not relate to the B. Arch. Programme per se; it has been articulated for the post-graduate course on urban planning, to be introduced by the Department in due course
Proposal of suitable solutions, and implementations, in compliance with regulatory requirements

Program Outcome:

1. Ability to identify needs, analyse issues, conceive and frame requirements, and provide appropriate architectural design solutions
2. Skills to use appropriate tools, software, and equipment for analysis and synthesis
3. Ability to represent and communicate effectively in both verbal and written form, using appropriate media and technologies
4. Understanding of impact of architectural solutions on the society and awareness of contemporary issues
5. Ability to work in a multidisciplinary environment and incorporate knowledge from various disciplines to improve design solutions
6. Knowledge of professional and ethical responsibilities
7. Necessary training to go in for higher academic programmes, employment in industry, or entrepreneurship

Process for defining the Vision and Mission of the Department and PEO of the programme:

The Department of Planning and Architecture, NIT Rourkela, presently offers a five year undergraduate programme in architecture, and doctoral research programmes for both architecture and urban and regional planning. In due course, the Department also intends to introduce a two year postgraduate programme in urban and regional planning. The undergraduate programme of the Department follows the guidelines set by the Council of Architecture, India (herein after referred to as the Council or CoA), and is subject to regular inspection, review, and approval by the Council. On successful completion of the course, the graduates are eligible for registration with the Council as ‘Registered Architect’s. Considering all of these, the vision and mission of the Department have been articulated by conducting a curriculum revision workshop with three external experts.

First Semester

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**Prerequisite:** Basic Design for Architectural Design I

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**Prerequisite:** Architectural Design I for Architectural Design II

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**Prerequisite:** Architectural Design II for Architectural Design III

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Prerequisite: Architectural Design III for Architectural Design IV

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Prerequisite: Architectural Design IV for Architectural Design V

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Prerequisite: Architectural Design V for Architectural Design VI

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Prerequisite: Architectural Design VI for each course

1. Professional Training Involves 100 days of off-campus training under a Registered Architect (refer Training Manual for details).
2. Components for evaluation of Professional Training:
   a. Trainer’s Feedback
   b. Training Portfolio

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TOTAL 19

Prerequisite: Architectural Design VI for Architectural Design VII

### TENTH SEMESTER

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TOTAL 13

Prerequisite: Architectural Design VII for Architectural Thesis Project

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TABLE OF MINOR DEGREE COURSES

Not offered.

INTEGRATED M.Sc.

DEPARTMENT OF CHEMISTRY

Curriculum of Integrated M.Sc. (Chemistry) (CY)

Vision:
To be a globally-recognized department committed to quality teaching and cutting-edge research in chemical sciences.

Mission:
1. To help every teacher and every student achieve his/her academic potential by providing appropriate scholastic environment.
2. To network with industry for the development of chemical science based technology.

Program Educational Objectives:
The Chemistry program at NIT Rourkela has the following educational objectives:

1. To prepare graduates with mastery of the basic chemical principles, and with the analytical problem-solving and communication skills, requiring the application of those principles.
2. To prepare graduates to become successful in their chosen career path, whether it is in the practice of Chemistry or in other complementary disciplines.
3. To produce graduates who are familiar with research design methodology and are able to organize and present the chemical information/results coherently through oral and written presentations.
4. To prepare graduates who are life-long learners.
5. To prepare graduates who will consider the broader context of social, political, environmental, economic, health and safety issues.
6. To demonstrate high standards of professional and ethical responsibility to become responsible citizens and leaders in the community and in the field of chemical sciences.

Program Outcomes:
Our Chemistry Program attempts to inculcate the following outcomes in its graduates:
1. To have a firm foundation in chemical principles as well as a higher level of understanding in each of the chemistry sub disciplines.
2. To have a firm knowledge on analytical instrumentations and laboratory techniques and be able to use those skills to design and conduct independent work, as well as to analyze and interpret data.
3. To know how to search primary chemical literatures, follow, and learn from scientific presentations, and give effective oral and written reports on various research topics.
4. To communicate effectively, both orally and in writing.
5. To function on multi-disciplinary teams.
6. To understand the professional, social, environmental, and ethical responsibility.
7. Life-long learning to meet the professional and personal goals.
8. To have knowledge of contemporary issues.

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**SUMMARY OF COURSES**

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### Sub Discipline: Laboratory Courses
### Sub Discipline: Project, Seminar and Special Courses

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### DEPARTMENT OF LIFE SCIENCE

**Curriculum of Integrated M.Sc. (Life Sciences)(LS)**

**Vision:**
To become a centre of excellence in teaching, research and extension activities of basic and applied biology, agriculture, health care and environmental protection.

**Mission:**
- To nurture and train young minds to deal with biological problems, and to understand the underlying mechanisms/rules of unsolved puzzles of nature.
- To establish state-of-the-art laboratory facilities to fulfil the needs of our academic and research programs and extend these facilities to other institutes and industries.
- To foster collaboration with major institutes and industries of repute involved in R&D activities related to biological sciences and healthcare.
- To open new employment opportunities to our students by giving rigorous and excellent training comparable to academic and industrial standards.

**Program Educational Objectives:**
- Students will be equipped to communicate scientific ideas orally and in writing effectively.
Students will take up a leadership role in academic and industrial sectors related to basic and applied biology, agriculture, health care and environmental protection.

Students will be able to think critically and evaluate, design, conduct, analyse and quantitatively assess the impact of innovative research in biological sciences.

Students will be trained to adhere to scientific ethics while practising the profession.

**Program Outcome:**

- Students will be able to apply their knowledge of life science, to design, conduct, analyse and interpret experimental results.
- Students will be able to identify, formulate and solve the problems related to biological sciences.
- Students will be able to work professionally in academic and industrial sectors.

**Process for defining the Vision and Mission of the Department and PEO of the program:** Views of all the stakeholders of the department like students, faculty members, parents, employers and alumni were initially considered. Vision and Mission of the Department and PEO of the program was then formulated and discussed again at the departmental level meeting. The vision and mission of the department and PEO of the program were then analysed and reviewed by the external experts from institutes of higher reputation. Then the finalised vision and mission of the department and PEO of the program was approved by Senate of the Institute subsequently by the Board of Governors of the Institute.

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### DEPARTMENT OF MATHEMATICS

**Curriculum of Integrated M.Sc. (MATHEMATICS)**

**Vision:**
To produce highly qualified and well-rounded mathematicians and researchers, technologists and engineering professionals having skills in mathematics, who can provide leadership and service to the nation and to the world.

**Mission:**
1. To pursue creative research in mathematics and related disciplines in order to serve the needs of society, scientific community and industry.
2. To develop partnership with industrial and government agencies, and other engineering and science professionals.

**Program Educational Objectives:**
1. To give the fundamental knowledge of mathematics and its application in various science and engineering problems.
2. To provide the opportunity to specialize in various areas and career aspirations related to mathematics and beyond.
3. To give rigorous training in practical problem solving and laboratory skills.
4. To provide an exhaustive education that includes communication skills, ability to function well on a team and ability to engage in academic achievements.

**Program Outcome:**
(a) Ability to apply knowledge of mathematics in various science and engineering problems.
(b) Ability to analyze and interpret data.
(c) Ability to design models for various mathematical problems.
(d) Ability to function in a multi-disciplinary team.
(e) Ability to communicate effectively.
(f) Recognition of the need and an ability to engage in life-long learning
(g) Ability to use the techniques, skills and modern mathematical tools necessary for practical purpose.
(h) Knowledge of different mathematical software and systems for various problems
(i) Knowledge of fundamental mathematical structures.

### THIRD SEMESTER

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DEPARTMENT OF PHYSICS & ASTRONOMY

Curriculum of Integrated M.Sc. (Physics & Astronomy) (PH)

Vision:
The department's goal is to establish itself as one of the most sought-after destination for highly motivated and curious young minds ready to undertake the fascinating journey of discovering the fundamental laws of nature.

**Mission:**
Our mission is to strike the perfect balance between providing quality education and carrying out research of highest possible standards in the fields of Physics and Astronomy.

**Program Educational Objectives:**
I. Keeping an eye on the ongoing research in the department as well in the world, one of our primary objective is to nurture and build young scientific minds by providing them a strong theoretical background and practical understanding of physical laws.

II. To build human resource with analytical minds and problem solving skills based on scientific thinking.

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DETAILED SYLLABI OF COURSES

B Tech/ Dual Degree

DEPARTMENT OF BIOMEDICAL ENGINEERING

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Living cell: Definition, structure and function, prokaryotic vs. eukaryotic cells, sub cellular organelles, function of cell organelles, structure and function of cell membrane, transport of substances across cell membrane, cell to cell junctions and communications; Cellular Metabolism: Carbohydrate metabolism, lipid metabolism, amino acids and protein metabolism, introduction to nucleic acid chemistry; Redox potential, Oxidative phosphorylation; Electrolytes: Acid base balance and biochemical measurement of acids –base and electrolyte status of the patients. Classification and identification of bacteria, microbial nutrition, microbial growth, sterilization and disinfection chemotherapeutic agents, genes: structure, replication, and mutation, expression and regulation, microbial recombination and plasmids, recombinant DNA technology, microbial genomics, the viruses: introduction and general characteristics,
bacteriophages, viruses of eukaryotes, the fungi, the algae, the protozoa, microorganisms in aquatic environments and terrestrial environments, pathogenicity of microorganisms, antimicrobial chemotherapy, clinical microbiology, the epidemiology of infectious disease, human diseases caused by microorganisms, industrial application of microorganisms.

**Essential Reading:**

**Supplementary Reading:**

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Definition of human anatomy and physiology, anatomical terms and planes; Skeletal system: Classification of bones, joints and muscles, major muscles of limbs and their actions. Functional concept of the human body, bone and muscle physiology; Cardio Vascular System: Structure & function of Heart & blood vessels, Special functional tissue of heart, E. C. G., Cardiac cycle, Blood pressure, Blood flow, Blood pressure regulation & controlling factors; Respiratory system: Upper and lower respiratory tract, Structure and Function of respiratory membrane, Pulmonary circulation, Mechanics of breathing, Transport and control of gases, Lungs volume and capacities, Regulation of respiration, Pulmonary function tests; Nervous system & special senses: Brain and spinal cord, peripheral autonomic nervous system, nerve physiology, EEG, MEG & ECG; Eye & ear; Endocrine Glands: types, location, description and functions; Digestive system: Parts of digestive system, gastro intestinal tract and associated glands; Urinary system: Parts and function of urinary system; Male and female reproductive system and Lymphatic system: Spleen, glands and lymph nodes.

**Essential Reading:**

**Supplementary Reading:**

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Essential Reading:

Supplementary Reading:

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The study of microbial structure, prokaryotic cell structure and function, microbial nutrition, microbial growth, morphology of bacteria, nutritional requirements of bacteria, media for bacterial growth, classification and identification of bacteria, sterilization and disinfection, chemotherapeutic agents, genes: structure, replication, and mutation, expression and regulation, microbial recombination and plasmids, recombinant DNA technology, microbial genomics, the viruses: introduction and general characteristics, bacteriophages, viruses of eukaryotes, microbial taxonomy, the archaea, bacteria: the deinococci and nonproteobacteria gram negatives, the proteobacteria, the low g + c gram positives, the high g + c gram positives, the fungi (eumycota), slime molds, and water molds, the algae, the protozoa, microorganism interactions and microbial ecology, microorganisms in aquatic environments and terrestrial environments, normal microbiota and nonspecific host resistance, pathogenicity of microorganisms, antimicrobial chemotherapy, clinical microbiology, the epidemiology of infectious disease, human diseases caused by viruses, bacteria, fungi and protozoa, microbiology of food, industrial microbiology and biotechnology.

Essential Reading:

Supplementary Reading:

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</table>
Need of biostatistics. Descriptive statistics: Population and samples; descriptive methods for categorical data; descriptive methods for continuous data; probability and probability distributions; types of data; frequency distribution; measures of central tendency; measures of variability; kurtosis and skewness; Z score. Inferential statistics: parameters; estimating and comparing the mean of population. Hypothesis testing: basic concepts and steps; testing normal distribution - Kolmogorov-Smirnov test; testing homogeneity of variance - Levene's test; Z-tests; dependent t-test, independent t-test, t-test as GLM, F-test, Chi-square test; Type I and type II errors; ANOVA, ANCOVA, factorial ANOVA, repeated-measures designs, mixed design ANOVA, post hoc procedures. Non-parametric and distribution-free tests - Mann-Whitney test; Wilcoxon signed-rank test, Wilcoxon signed rank sum test, Kruskal-Wallis test, Friedman's ANOVA. Correlation techniques: bivariate correlation - Pearson's correlation coefficient, Spearman's correlation coefficient; Partial correlation; regression - method of least squares, assessing goodness of fit; multiple regression. Experimental design and clinical trials.

**Essential Reading:**


**Supplementary Readings:**


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<tbody>
<tr>
<td>BM2011</td>
<td>Analytical Techniques</td>
<td>3</td>
<td>A. Sarkar</td>
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</tbody>
</table>

Basic Techniques, Microscopy- Dark-field, Phase contrast, Fluorescence, Confocal, Polarization microscopy; Electron microscopy: TEM & SEM, Radioisotope techniques- Basic concepts, GM and scintillation counter, autoradiography, RIA, Applications in biological science, Chromatographic methods- General principles, Ion exchange, Gel filtration, Affinity and Gas chromatography techniques, HPLC, Electrophoresis- General principles, Horizontal & Vertical Gel electrophoresis, Isolelectric focusing, 2D, Pulse field and immune-electrophoresis, Centrifugation techniques- Basic principles, Different types of centrifuges, Analytical and Preparative Ultracentrifugation methods, Spectroscopic Techniques- Electromagnetic radiations; UV-Visible, fluorescence, CD, NMR, X-ray, Atomic absorption and Flame emission spectroscopic techniques, Mass spectrometry, Polymerase Chain Reaction, DNA sequencing, ELISA, Micro array, In-situ Hybridization

**Essential readings:**


**Supplementary Reading:**


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<tbody>
<tr>
<td>BM2101</td>
<td>Cell And Molecular Biology</td>
<td>3</td>
<td>B. P. Nayak</td>
</tr>
</tbody>
</table>

Introduction: Eukaryotic vs. Prokaryotic cell, Components of Eukaryotic Cell (cell membranes, subcellular organelles, cytoskeleton); Cell Junctions: Types and structure of junctions (Desmosomes, Hemi-desmosomes, Adherens junctions, Tight junctions, Gap junction); Cell Adhesion Molecules: classification (NCAM, Cadherin, Integrins etc.), function; Cell surface Receptors: Ion linked Receptors, Enzyme Linked Receptors, Cytokine Receptor superfamily,
GPCR; Signal Transduction via Surface Receptors: Emphasis on GPCR pathways, cAMP Signaling from Receptor to Function; Dual Signaling Pathway: Inositol phosphates and protein kinase C, calcium & calmodulin; Cross-Talk, signal amplification & cascade mechanisms; Microtubules & Motor Proteins; microfilaments, myosins, and microbes; Chemotaxis: chemokines, chemokine receptors& the Inflammatory response; Receptor-Mediated Endocytosis; Vesicle Trafficking: COPs, SNARES; Cell Cycle: stages, regulation of cell cycle specific genes, cellular aspects of cancer, cellular, oncogenes and gene therapy.

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>BM2300</td>
<td>Bioprocess Engineering-I</td>
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**Essential Reading:**

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<tbody>
<tr>
<td>BM2401</td>
<td>Environmental And Safety Engineering</td>
<td>3</td>
<td>A. Sarkar</td>
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</table>

**Environmental Engineering:**
Introduction to Environmental engineering Nature and scope of environment problems;

**Environmental hazards:**
- Physical hazards: Noise, compensation aspects, noise exposure regulation, properties of sound, occupational damage, risk factors, sound measuring instruments, octave band analyzer, noise networks, noise surveys, noise control program, industrial audiometry, instruments, surveying procedure, permissible exposure limit, radar hazards, microwaves and radio-waves, lasers, thermal comfort, heat stress indices, acclimatization, estimation and control
- Chemical hazards: Recognition of chemical hazards, Industrial hazards-oxic substances, dust, fumes, mist, vapour, fog, gases, types, concentration, Exposure vs. dose, TLV - Methods of Evaluation, process or operation description, Field Survey, Sampling methodology, Industrial Hygiene calculations, Comparison with OSHAS Standard.
**Biological and ergonomical hazards:** Classification of Bio hazardous agents – bacterial agents, rickettsial and chlamydial agents, viral agents, fungal, parasitic agents, infectious diseases - Biohazard control program for solid, liquid wastes, employee health program- laboratory safety program-animal care and handling-biological safety cabinets. Environment Management and Sustainability Tools for sustainable management including ISO certification, environment audit, EIA and LCA; National and International policies, regulations and institutions.


**Essential Reading:**

**Supplementary Reading:**

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<tbody>
<tr>
<td>BM2500</td>
<td>Biomechanics</td>
<td>3</td>
<td>A. Thirugnanam</td>
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</table>

Introduction – Force vectors, Coplanar, collinear and concurrent forces, moment and torque, Statics: Analysis of systems in equilibrium, Applications of statistics to Biomechanics, Mechanics of elbow, shoulder, spinal column, hip, knee, ankle.

Introduction to deformable body mechanics, stress and strain, plastic deformation, multiaxial deformations and stress analysis, mechanical properties of biological tissues, various testing methods, empirical model of visco-elasticity, biomechanics of bone, tendons, ligaments, muscles and cartilages.

Introduction to dynamics, linear kinematics and kinetics, angular kinematics and kinetics, work-energy methods, conservation of energy principle, Application to athletics, impulse and momentum. Computational biomechanics, continuum mechanics.

Gait analysis, measurement of gait parameters, techniques for recording and measuring movements and forces - force platforms and motion analysis system, Applications of these equipments in biomechanics, performance improvement and injury prevention.

**Essential Reading:**

**Supplementary Reading:**
Introduction, Energy Transformation, system and surroundings, Internal energy, Work, heat capacity, First law of thermodynamics, energy conservation in the living organisms. The second law of thermodynamics, entropy, isothermal systems, Protein denaturation, The third law and biology, Irreversibility and life.

Gibbs free energy – reversible processes, phase transitions, chemical potential, effect of solutes on boiling points and freezing points, ionic solutions, equilibrium constant, chemical coupling, redox reactions. Applications of Gibbs free energy (photosynthesis, substrate cycling, osmosis, dialysis, membrane transport, enzyme substrate interaction, protein solubility, stability and dynamics, ELISA, non equilibrium thermodynamics etc). Statistical thermodynamics, binding equilibria.

Reaction kinetics – Introduction, Rate of reaction, rate constant and order of reaction, First and second order reaction, temperature effects, collision theory, transition state theory, electron transfer kinetics, enzyme kinetics, inhibition, reaction mechanism of lysozyme, hydrogen exchange, protein folding and pathological misfolding, polymerization, muscle contraction and molecular motors. The frontier of biological thermodynamics.

**Essential Reading:**

**Supplementary Reading:**

Introduction, revision of the basic principles of fluid mechanics, heat and mass transfer, Physiological properties of biological fluids and tissues; Non-Newtonian fluid flow.

**Essential Reading:**

**Supplementary Reading:**
1. C. G. Geankoplis, Transport Processes and Unit Operations, Allyn and Bacon, Boston, 1983.

Determining the muscle fatigue limit during isotonic and isometric muscle contractions, Determination of moment force at various angles of bicep muscle and to calculate its mechanical advantage, Determination of maximum load of bicep muscle at various joint
angles, Gait analysis of normal walking using force platform and 3-D motion capture system, Kinematic study of arm flexion, Verification of Bernoulli’s theorem, determination of coefficient of discharge for different flow rates through orificemeter and venturimeter, Study of flow characteristics using Reynold’s apparatus.

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<tr>
<td>BM2701</td>
<td>Medical Science Lab</td>
<td>2</td>
<td>S. S. Ray</td>
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</tbody>
</table>

Identification of various organs and skeletal parts from charts and models, Preparation of slices from tissue, fixation and examination under microscope, Preparation of blood film, staining and examination under microscope, TLC, DLC estimation of blood, Recording the ECG, EEG and EMG signal, Recording respiratory parameters through spirometry, Examination of eye with direct ophthalmoscope, Training on Human patient simulator, Morphometric of human femur, skull and pelvis from CT Scan Images, Blood grouping and Widal tests.

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<tr>
<td>BM2702</td>
<td>Cell And Molecular Biology Lab</td>
<td>1</td>
<td>BP Nayak</td>
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</table>

Welcome to laboratory, introduction to laboratory equipment and learning safety and aseptic measures while working on wet bench/clean room; Basic principle of microscopy: hands on experience with light and inverted fluorescence microscope, working with magnification, resolution and visibility, aberrations, control of illumination in the microscope; Cell count, differential count and cell viability assay: use of Neubauer chamber, smear preparation and staining; Labeling techniques in fluorescence microscopy (labeling with antibodies, labeling with toxins and other specific molecules, labeling with substrate and ligand); Isolation and purification of DNA using CTAB method; Gel electrophoresis for DNA; Isolation and purification of total RNA by adsorption and elution method; Amplification of DNA by polymerase chain reaction; DNA amplification and real time estimation using real time PCR device by SYBR green method; Western blotting.

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<tr>
<td>BM2703</td>
<td>Biochemistry and Microbiology Lab</td>
<td>1</td>
<td>B. P. Nayak</td>
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</table>

Biochemistry: Measurement of pH of biological liquids with pH-meter (ion meter); Quantitative determination of iron ions in solution by a photoelectrocolorimetric method; Quantitative determination of serum protein by Bradford method using UV spectrophotometer; Quantitative determination of blood glucose by glucose oxidase method using semi-automated biochemical analyzer; Quantitative determination of urea in 24hr urine using semi-automated biochemical analyzer and comparison with dipstick method.

Microbiology: Preparation of general purpose microbiological growth media using TSA/TSB (tryptic soy agar/broth); Introduction to microscopy: to learn the principle and use of compound light microscope; Bacterial culture: to culturing bacteria by streak culture using aseptic technique; Simple staining: to stain bacteria under using safranin and crystal violet and visualize under light microscope; Gram staining: to learn gram staining protocol for classifying the Gm+ve and Gm-ve bacteria.

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<tr>
<td>BM2704</td>
<td>Transport Processes In Biological System Lab</td>
<td>1</td>
<td>A. Thirugnanam</td>
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</table>

Introduction to Clinical Laboratory Science, Safety in the Clinical Laboratory, Collection and Processing Laboratory Specimens, Clinical Chemistry, Principles of biochemical tests, complete blood count (CBC), comprehensive metabolic panel (CMP), electrolyte panel, liver function tests (LFT), renal function tests (RFT), thyroid function test (TFT), urinalysis, coagulation profile, lipid profile, blood type, semen analysis (for fertility and post-vasectomy studies), serological studies and routine cultures. Use of the Microscope, Fixation, Decalcification, Dehydration, Impregnation and Embedding Techniques, Biological Staining, Staining Procedures, Sterilization, Serological tests, antigen-antibody test kits, PCR, RT-PCR, Forensic tests, Cytological Techniques, ELISA and Chemiluminescence assays, Immunofluorescence assay, Diagnostic tests in medicine, dermatology, obstetrics & gynaecology, ophthalmology, ENT, orthopaedics etc., Rapid diagnostic tests and kits, Laboratory Measurements: Apparatus and Principles, Photometry, Laboratory Mathematics, Quality Assurance in the Clinical Laboratory, Automation in the Clinical Laboratory. ECG, EEG, EMG signal acquisition and interpretation, X-RAY, CT-Scan, MRI, USG imaging and image analysis and interpretation.

**Essential Reading:**

**Supplementary Reading:**

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<tbody>
<tr>
<td>BM3001</td>
<td>Analytical Instrumentation And Techniques</td>
<td>3</td>
<td>A. Sarkar</td>
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</tbody>
</table>

Introduction to spectrometry-Properties of electromagnetic radiation, wave properties, components of optical instruments, Sources of radiation, wavelength selectors, sample containers, radiation transducers, Signal process and read outs, signal to noise ratio, sources of noise, Enhancement of signal to noise, types of optical instruments. Principle of Fourier Transform optical Measurements.

Molecular spectroscopy-Molecular absorption spectrometry, Measurement of Transmittance and Absorbance, Beer's law, Instrumentation, Applications; Theory of fluorescence and Phosphorescence, Instrumentation, Applications; Theory of Infrared absorption spectrometry, IR instrumentation, Applications; Theory of Raman spectroscopy, Instrumentation, applications. Magnetic resonance spectroscopy and mass spectrometry- Theory of NMR, environmental effects on NMR spectra, chemical shift- NMR spectrometers, applications of 1H and 13C NMR, Molecular mass spectra, ion sources, Mass spectrometer, Applications of molecular mass, Electron paramagnetic resonance - g values, instrumentation.

Separation methods- General description of chromatography, Band broadening and optimization of column performance, Liquid chromatography, Partition chromatography, Adsorption chromatography, Ion exchange chromatography, size exclusion chromatography, Affinity chromatography, principles of GC and applications, HPLC- Capillary electrophoresis, Applications.

Electro analysis and surface microscopy- Electrochemical cells, Electrode potential cell potentials, potentiometry, reference electrode, ion selective and molecular selective electrodes, Instrument for potentiometric studies, Voltametry, Cyclic and pulse voltametry, Applications of voltametry, Study of surfaces, Scanning probe microscopes, AFM and STM.

Advanced techniques-Protein crystallization; Theory and methods; API-electrospray and MALDI-TOF; Mass spectrometry; Enzyme and cell immobilization techniques; DNA & Peptide Synthesis.
Essential readings:

Supplementary Reading:

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<tr>
<td>BM3002</td>
<td>Clinical Science</td>
<td>3</td>
<td>S. S. Ray</td>
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</table>

Pharmacokinetics, Pharmacodynamics, Drug dose, Enzyme kinetics, and Autonomic nervous system drugs, Hormonal medicine, cardiovascular and renal medicine, Chemotherapeutics and antibiotics, Neuropsychiatric drugs, Drug side effects, Cause of cancer, solid tumours of the body, Basics of Embryology, histopathology of normal and abnormal body tissues, Different type of blood cells and pathologies, Different types of microbes, Bacteria, Virus, fungal disorders, Protozoa and nematodes, Blood borne infections, Sign and symptoms, Gait analysis and orthopaedic Detail anatomy of Eye and general ophthalmic disorders, Problems during anaesthesia, ventilation, Emergency treatment, Different types of surgical procedure, Pre-operative and Postoperative Care, Pregnancy and Labour, Common gynaecological and obstetrical problems, Common Skin and ENT disorders, Medical diagnostics, Advantage and disadvantages of different diagnostic Procedure, common Instruments for Diagnostics and therapeutics.

Essential Reading:

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<tr>
<td>BM3003</td>
<td>Fluorescence Techniques in Biotechnology</td>
<td>3</td>
<td>N. Sarkar</td>
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</table>

Luminescence, Basic concepts in fluorescence; quantum yield, time resolved and steady state fluorescence; fluorescence lifetime measurements; Fluorescence quenching and its applications: static and dynamic quenching; Fluorescence Resonance Energy Transfer and its applications; Fluorescence anisotropy and its applications; Biochemical fluorophores; intrinsic and extrinsic fluorophores; Fluorescent proteins and their applications; green fluorescent proteins, Fluorescence sensing; Fluorescence applications in DNA technology; cellular imaging, protein folding, biomolecular interaction, fluorescence microscopy, fluorescence in forensic analytical techniques; Molecular beacons and their applications; Quantum dots and their applications.
Essential Reading:

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<tr>
<td>BM3004</td>
<td>Biotechnology In Human Health</td>
<td>3</td>
<td>M. K. Gupta</td>
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<tr>
<td>BM3006</td>
<td>Nanobiotechnology</td>
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<tr>
<td>BM3100</td>
<td>Applied Cell Biology</td>
<td>3</td>
<td>I. Banerjee</td>
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</table>

Essential concepts of animal cell biology. Quantitative aspect of cell biology. From cells to tissue: different forces playing across the length scale. Cell-cell and cell-material interaction, Modulation of cell adhesion, migration, proliferation, differentiation and cell death, Endocytosis, Mechano-transduction, Electrophysiology of cells, action potential, bio-impedance, Stem cell, Cell culture and characterization of cells, Concepts of Immuno-compatibility, Interface of cell biology with pharmaceutical technology, nanotechnology, biomedical engineering, tissue engineering and regenerative medicine. Cells as therapeutics, bioreactor, biosensor, biobattery and bioengineering building block. Ethical aspects of applied cell biology

Essential Reading

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<tr>
<td>BM3101</td>
<td>Genetic Engineering</td>
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<td>M. K. Gupta</td>
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<tr>
<td>BM3102</td>
<td>Cell And Tissue Engineering</td>
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<tr>
<td>BM3103</td>
<td>Immunology</td>
<td>3</td>
<td>I. Banerjee</td>
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Overview of the mammalian immune system, Evolutionary perspective of immunity and self defense, Innate immunity, adaptive immunity and its characteristics, Antigen and immunogen, Antigen presenting cells and antigen presentation, MHC molecules, Humoral immunity: Structure and function of antibody, antibody diversity, B cell maturation, B cell receptor for antigen, Cell mediated immunity: T cell diversity and their function, maturation of T cell, T cell receptor for antigen, interdependence of humoral and cell mediated immunity, Complement system. Toll-like receptors: structure, function and cellular expression, Transplantation immunology, Autoimmune disorder, Allergy and hypersensitivity, Immunopathology.

**Essential Reading:**

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<tr>
<td>BM3104</td>
<td>Immunotechnology</td>
<td>3</td>
<td>I. Banerjee</td>
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</table>

Essential concepts of immunology, Antigen (classification and characteristics), Immunization, Adjuvant, Vaccines, Use of antibody in diagnostics and therapy, Antibody (Production and purification), Hybridoma Technology: Production of monoclonal antibody, Immunoassays and related screening techniques: Enzyme linked immunosorbent assay (ELISA), Paper radio immunosorbent test (PRIST), Radio immuno assay (RIA), Immunocytotchemistry and Immunohistochemistry (ICC & IHC), Immunoblotting (Western blotting), Chemiluminescence immunoassay and Flow cytometry, Lab-on-chip devices for immunoassay, Adaptive immune cell therapy, Tetramer Technology, Dendritic cell vaccine for cancer, Antibody Engineering, Production of human monoclonal antibody, Immunotechnology in transplantation: Tissue typing, Use of immunotherapeutics: Safety, regulation and ethics

**Essential Reading:**

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<tr>
<td>BM3105</td>
<td>Recombinant DNA Technology</td>
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<td>M. K. Gupta</td>
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Strategies of gene cloning, tools in rDNA technology, methods of construction of rDNAs, methods of introduction of rDNAs into living systems, screening of rDNA clones, PCR, RFLP, DNA fingerprinting and footprinting, chromosome walking, blotting techniques, gene sequencing and mapping, gene targeting, in vitro gene expression systems and protein engineering, transgenesis, metabolic engineering, examples of pathway manipulations, site-specific and oligonucleotide-directed mutagenesis, antisense and ribozyme technology, gene therapy, ethical and legal issues in rDNA technology.

**Essential Reading**

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<td>BM3106</td>
<td>Biomolecular Engineering</td>
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<td>S Paul</td>
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Biomolecules definition, their function in cells - Proteins, Nucleic acid, starch and their basic structure. Various forces that determine biomolecule structure. Mechanisms of protein folding, characterization of folding pathways. Melting points and importance, biomolecules stability. Denaturants, determination of biomolecule structure by various spectroscopic techniques. Background and basic principles, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, NMR, X-ray crystallography, DSC. Protein denaturation, aggregation and gelation.; Gene cloning: Restriction enzymes in gene cloning, PCR technology for gene/DNA detection, cDNA, usages of plasmid and phages as vectors; Model vectors for eukaryotes-Viruses, Gene libraries; Use of marker genes; Medicine related applications i.e. commercial synthesis of hormones and vaccines. Microbial applications i.e. large scale preparation of organic chemicals, large scale biomolecules production and their other industrial applications.

**Essential Reading:**

**Supplementary Reading:**
History and scope of animal biotechnology. Animal cell and tissue culture: Aseptic technique; culture media; buffer systems; growth factors, supplements and substrates; initiation and maintenance of cell cultures; growth curve of animal cells in culture; animal cell cryopreservation techniques; immortalized culture and development of cell lines; suspension culture; perfusion and continuous flow cultures; scaling up of animal cell cultures; bioreactors for animal cell culture; mass transfer in animal cell culture; animal tissue culture techniques, organ culture. Animal genetic engineering: Introduction to cloning and gene technology, transfection of animal cell lines, Selectable and non-selectable markers, expression of cloned proteins in animal cells, vaccine development, development of Mabs. Transgenic animals - PN injection, viral vectors, SCNT, SMGT. Breed improvement: Economic traits; quantitative traits; upgrading; progeny testing; marker assisted selection; estrous synchronization; AI, superovulation, MOET, embryo splitting, ART, IVF. Animal biotechnology for in vitro and in vivo testing of drugs, toxicity testing of environmental pollutants, production of vaccines, pharmaceutical proteins and secondary metabolites. Bioethical issues related to animal biotechnology

Essential Reading:

Supplementary Reading:
**BM3200 Biopolymers 3 D. Verma**

Introduction to polymers and biopolymers; Molecular architecture of proteins, DNA polysaccharides and bacterial polyester; Structure function relationships in biopolymers; Multifunctional aspects of biopolymers; Application of biopolymers in drug delivery and regenerative medicine; Biopolymers in bio-composites; Biological response of biopolymers; biodegradation of biopolymers; Environmental and economic aspects of biopolymers.

**Essential Reading:**

**Supplementary Reading:**

**BM3201 Biomaterials 3 A. Biswas**


**Essential Reading:**

**Supplementary Reading:**
1. J. Black, Biological Performance of materials, Taylor &Francis,2006
Introduction to composites, Potential of Biocomposites for Medical Applications, Constituent, Fabrication, and Characterization, synthetic biocomposites and natural biocomposites; Structure function relationships in natural biocomposites; hierarchical structures in natural biocomposites; Mechanics of composite materials, Different approach to prepare biocomposite materials, Multifunctional aspects of biopolymers; biomimetics synthesis and design methods of synthetic biocomposites; biomedical applications of biocomposites - bone plates, intramedullary nails, total hip replacement, bone grafts, dental materials, prosthetic sockets, tendons and ligaments, vascular grafts. Environmental and economic aspects of biocomposites.

**Essential Reading:**

**Supplementary Reading:**

Introduction to nano, Nanotechnology definition, properties of nanoscale matrices, nanobio mimicry, synthesis of nanomaterials by physical, chemical and biological methods, characterization of nanomaterials, DNA nanotechnology, protein and glycol nanotechnology, lipid nanotechnology, lipid nanotechnology, bio-nanomachines, carbon nanotube and its bio-application. Nanomaterials for cancer diagnosis, nanomaterials for cancer therapy, nanotechnology in tissue engineering, nano artificial cells, nanomaterials in drug delivery and imaging, nanobiodevices and nanotoxicology, nanopharmacology and drug targeting. Cellular uptake mechanisms of nanomaterials, In vitro methods to study antibacterial and anticancer properties of nanomaterials, nanotoxicology.

**Essential Reading:**

**Supplementary Reading:**
Introduction to bioreactor, Parts of bioreactor, Pressure measurement, level measurement, flow measurement, temperature & heat measurement, humidity measurement, density measurement, viscosity measurement, pH measurement, Redox potential measurement; Dissolved oxygen measurement, photodetectors, Gas analysers, Analytical instruments: UV spectrophotometer, Fluorescence spectrophotometer, CD spectrophotometer, light scattering spectroscopy, atomic absorption spectroscopy. Actuators & control; Process control → Control modes, Implementation of control loops, Digital controllers; Documentation and symbols.

**Essential Reading:**

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<tr>
<td>BM3303</td>
<td>Biochemical Engineering</td>
<td>3</td>
<td>K. Pramanik</td>
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Introduction, Enzyme and its applications, Enzyme Kinetics, Biokinetic parameters, enzyme reactor systems, Inhibition of enzyme reactions, Effects of pH, temperature and shear, enzyme immobilisation & kinetics, Immobilized enzyme reactors, Cell growth kinetics, batch, Plug Flow and Continuous stirred tank fermentors, multiple fermenter in series, fermenter with cell recycling. Sterilization methods, Thermal death kinetics, Batch and continuous sterilization. Agitation and aeration importance, correlation for mass transfer coefficient, interfacial area, mechanical agitation, Gas hold-up, power consumption, oxygen absorption rate, bioreactor scale-up, separation of bioproducts.

**Essential Reading:**

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<tr>
<td>BM3305</td>
<td>Bioprocess Optimization</td>
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General overview of bioprocesses, Basic fundamentals and principles of bioprocess optimization, Role and significance of bioprocess optimization in biotechnology industry. Criteria for good medium - Medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, Medium formulation of optimal growth and product formation, examples of simple and complex media, Design and usage of various commercial media for industrial fermentations. Experimental designs, Factorial experiments – two factors and 2k factorial experiments, Statistical analysis, ANOVA. Central composite designs, Box Benhen designs. Medium optimization methods, Plackett-Burman designs, Taguchi designs and Response Surface Methodology. Case studies and success stories, Modern software tools for bioprocess optimization.

**Essential readings:**


**Supplementary Reading:**


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<th>Sub. Code</th>
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<tbody>
<tr>
<td>BM3400</td>
<td>Environmental Biotechnology</td>
<td>3</td>
<td>P. Balasubramanian</td>
</tr>
</tbody>
</table>

Basics of environmental biotechnology, Microbial growth and metabolism; Respiration and energy generation; Enzyme kinetics and regulation, microbial transformation reactions (aerobic and anaerobic biotransformations). Bioremediation technology and influencing factors, Types – phytoremediation, bioventing, bioleaching, land farming, bioreactor, composting, bioaugmentation, rhizofiltration, biostimulation. Bioremediation systems and processes (solid, liquid and slurry phase bioremediation); Microbial cleaning of gases (biofiltration and bioscrubbing); In situ bioremediation; Biotreatability studies. Microbial detoxification of persistent organic pollutants (POPs) and endocrine disruptors (insecticides, herbicides, fungicides, polychlorinated biphenyls, heavy metals). Environmental monitoring-bioreporter, biomarker and biosensor technology. Biological energy and biomass production from waste. Environmental impact assessment, Biodiversity and its conservation, GMOs and Biosafety. Ethical issues in environmental biotechnology.

**Essential Reading:**


**Suggested Reading:**


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<tbody>
<tr>
<td>BM3401</td>
<td>Agricultural Biotechnology</td>
<td>3</td>
<td>A. Sarkar</td>
</tr>
</tbody>
</table>

Plant cell structure and function, Protection against infections, Microbial groups in soil, Microbial transformations of carbon, nitrogen, phosphorus and sulphur, Biological nitrogen fixation. Microflora of Rhizosphere and Phyllosphere microflora, microbes in composting, Tissue culture and its application, Micropropagation and molecular farming, Meristem culture and production of virus-free plants, Embryo and ovary culture, Protoplast fusion-somatic hybrids, cybrids. Somaclones, Synthetic seeds, In vitro germplasm conservation, Cryopreservation, Organelle DNA, Satellite-and repetitive DNAs. DNA repair. Regulation of gene expression. Methods of gene transfer in plants, Gene gun, Protoplast fusion, Agrobacterium mediated gene transfer etc. Achievements and recent developments of genetic engineering in agriculture. Development of transgenies for biotic and abiotic stress tolerance, Molecular tools in
Agricultural Biotechnology, microarray, bioethics, terminator technology, nanotechnology, DNA finger printing, gene silencing. Microbiology of food: microbial spoilage and principles of food preservation. Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial Cyanobacterial and Fungal), microbial insecticides, Microbial agents for control of Plant diseases, Biodegradation, Biogas production, Biodegradable plastics, Plant - Microbe interactions.

**Essential Reading:**

**Supplementary Reading:**

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</thead>
<tbody>
<tr>
<td>BM3402</td>
<td>Biotechnology In Agriculture And Natural Products</td>
<td>3</td>
<td>N. Patra</td>
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</tbody>
</table>

Effect of environmental stress and pollutants on food crops and cattle; Plant protease inhibitors for development of pest resistant crops; Phytoremediation and biocontrol of nematodes; parasites of cattle; formulation of pesticides from plant sources, Effect of sewage and sludge on vegetables growing in contaminated soils, blood-sugar lowering herbs for diabetes control; responses to pesticides for effective pest resistance, critical concentrations of heavy metals and phytoremediation of heavy metals.

**Essential Reading:**

**Supplementary Reading:**

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<tbody>
<tr>
<td>BM3403</td>
<td>Bio-Resources And Technology</td>
<td>3</td>
<td>K. Pramanik</td>
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</tbody>
</table>

Bioconversion of agro-industrial residues, liquid and gaseous biofuel production, Physico-chemical & thermo-chemical processes for biomass, Advances in Biological Wastewater Treatment, Biobeneficiation, Biofiltration, Biological Control of Air Pollution, Bioremediation, Availability of different organic wastes; Characteristics of the solid and liquid wastes; Cell growth and product formation kinetics; Different bioenergy generation processes: biomethanation, biohydrogen, bioethanol, biodiesel; Bioreactor design and analysis, Different advanced bioreactors; Comparative analysis on different bioenergy generation processes; Energy and material analysis of the process; Scaling up problems; Economic analysis of the process, Management of natural bioresources, recycling and conversion of organic wastes.
Essential Reading:

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<tbody>
<tr>
<td>BM3404</td>
<td>Biosensor Technology</td>
<td>3</td>
<td>A. Biswas</td>
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</table>

Introduction to sensors, transducers, biosensors, bioreceptors, transducer for biosensors. Classification of transducers, selection of transducers, Temperature transducers, Displacement transducers, Pressure transducer, photoelectric transducers, Flow transducers, piezo-electric transducers and their applications; Electrochemical transducer in Biology and medicine; Biochemical Transducer; Electrode theory: electrode-tissue interface, metal-electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams; Biopotential electrodes, Reference electrodes, Recording electrodes for ECG, EEG and EMG. Enzyme-based electrochemical biosensors; Fabrication and miniaturization techniques; Optical technology and principle of optical measurements; Immunosensors; Living Biosensors.

Essential Reading:

Supplementary Reading:

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<tr>
<td>BM3405</td>
<td>Food Technology, Safety And Quality</td>
<td>3</td>
<td>M. K. Gupta</td>
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Essential Reading:


Supplementary Reading:


5. Food Safety and Standards Act and Regulations by FSSAI.

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<tbody>
<tr>
<td>BM3406</td>
<td>Biological Waste Treatment</td>
<td>3</td>
<td>P. Balasubramanian</td>
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Essential Reading:


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<tr>
<td>BM3408</td>
<td>Green Energy Technology</td>
<td>3</td>
<td>P. Balasubramanian</td>
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</table>

Overview of major global energy issues, Risk and hazard assessment in the energy sectors, Need for green energy technologies. Environmental impacts of fossil fuel based power generation, Constraints on hydropower and wind energy. Green chemistry – Principles and Methodologies, quantitative/ optimization based frameworks for the design of green chemical synthesis pathways, Pollution prevention in material selection. Energy production via chemical

**Essential Reading:**

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<tr>
<td>BM3500</td>
<td>Biofluid Mechanics</td>
<td>3</td>
<td>A. Thirugnanam</td>
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**Essential Reading:**

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<tbody>
<tr>
<td>BM3501</td>
<td>Transport Phenomena In Unit Operation</td>
<td>3</td>
<td>A. Thirugnanam</td>
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<tbody>
<tr>
<td>BM3502</td>
<td>Biotransport</td>
<td>3</td>
<td>A. Thirugnanam</td>
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<tr>
<td>BM3600</td>
<td>Occupational Safety and Hazards</td>
<td>3</td>
<td>B. P. Nayak</td>
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</tbody>
</table>

Define occupational health, Principles of occupation health and safety (OSHA guidelines), Elements of work environment (the worker, the tools, the process, the work environment), Aims of occupational health and safety (by WHO); Occupational safety goals, Occupational safety measures, personal protective equipment (for head, ears, eyes, respiratory system, reproductive system).

Occupational hazards: Physical hazards i.e. Heat and cold (direct heat, indirect heat, radiant heat), Light(Poor illumination or excessive brightness), Noise(auditory effects, non-auditory effects), Vibration, Ultraviolet radiation, Ionizing radiation; Chemical hazards i.e. Corrosives, oxidizing agents, harmful agents, toxic agents, Irritants, highly inflammable agents, explosives; Biological agents. Hazard prevention and monitoring: Evaluation methods, Exposure monitoring (Infrared absorptiometry, photoionization, gaschromatography), Engineering controls (Building design, substitution measures, emission measures, containment methods, localexhaustventilation, PPE design, remote operation), legislation.

Essential Reading:
1. James P. Kohn and Mark A. Friend; Fundamentals of Occupational Safety and Health; 5th edition (Barnes & Noble)

Supplementary Reading:
Introduction: general vs. biomedical instrumentation, block concept of biomedical instruments (sensor, processor and display), properties of each part in general, Processing functions of an instrument (amplification, modulation/demodulation, ADC and DAC, frequency selection, wave shaping etc.); Characteristics of Instruments: static characteristics, dynamic characteristics with order of instruments, principle of working of 1st and 2nd order instruments in response to pulse, step and sinusoidal inputs; Controller: Concept of instrument control (feed backward and feed forward), principles of proportional, integral and derivative control, PID algorithm; Sensors of Biomedical importance: variable resistive transducers (strain gauge), variable inductive transducers (LVDT), variable capacitive transducers, photoelectric transducers, piezoelectric transducers, Body temperature measurement: thermal equilibrium of human body, routes of temperature measurement, core and brain temperature, thermal transducers (Thermistors, RTDs, Thermocouples, Pyrometers), new concepts of brain temperature measurement.

Essential Reading:
1. J. Webster, Bioinstrumentation (Wiley & Sons. 2004).

Supplementary Reading:

Sub. Code | Subject | Credit | Course Caretaker
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BM3602 | Medical Imaging | 3 | S. S. Ray

X-rays production & properties, various components of radiographic systems, types of X-ray tubes for various medical applications; Principle of CT Scan, Optical Coherence Tomography, Dual-Energy CT Imaging, Four-Dimensional Computed Tomography, Image Reconstruction Algorithms for X-Ray CT, PET Detectors, Recent Developments of High-Performance PET Detectors, CT-SPECT/CT-PET, Multimodality Imaging with MR/PET and MR/SPECT, Image Reconstruction for 3D PET, Multicoil Parallel MRI, Diffusion MRI, T1and T2 MR Imaging: Principle, Technology, and Application, Pulse sequencing in MRI, Functional MRI, Medical Image Registration, Medical Image Segmentation: Medical Infrared Imaging, Infrared Detectors and Detector Arrays, Infrared Camera Characterization, Infrared Camera and Optics for Medical Applications, Principles of Ultrasonography, Ultrasound Imaging System Design and Hardware Considerations, Electrical Impedance Tomography, Principle of photography and radiographic film image, film densitometry, information content of an image, image quality factors, Fluoroscopic imaging system, Digital subtraction angiography (DSA), digital subtraction programming; Radiotherapy principles, dosage for clinical applications, radiation therapy planning, collimators and beam direction devices, dose measurement and treatment planning, Detectors- ionization chamber, proportional counter, Geiger- Muller counter scintillation detectors, Safety protocols & protection; Contrasting agents in Medical Imaging.

Essential Reading:

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<tr>
<td>BM3603</td>
<td>Biomedical Signal Processing</td>
<td>3</td>
<td>K. Pal</td>
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</table>

Basics of digital signal processing: Sampling theorem, continuous and discrete LTI system; Introduction to Z Transform: The Z transform, properties of Z transform, inverse Z transform, transfer function in Z domain, location of poles and zeroes of Z-domain; Discrete Fourier Series and Transform-Discrete Fourier series, Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT); Digital Filters Realizations: Characteristics of FIR filters, frequency response, design of FIR filters. Design of IIR filters from analog filters: bilinear transformation method, step and impulse invariance techniques.

Introduction to biomedical signals: ECG, EMG, EOG, EEG. Digital signal processing techniques for biomedical signals. Designing criterion for pacemaker and biofeedback systems.

**Essential Reading:**

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<tr>
<td>BM3604</td>
<td>Biomedical Instrumentation- II</td>
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<td>B. P. Nayak</td>
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<tbody>
<tr>
<td>BM3700</td>
<td>Programming and Simulation Lab - I</td>
<td>1</td>
<td>A. Thirugnanam</td>
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</table>

Finding out matrix addition, multiplication, inversion, rank, Eigen values using MATLAB simulator.; Plotting set of data using MATLAB; Parameter estimation using least-square
technique using MATLAB; Writing ‘m’ files in MATLAB platform to solve coupled linear algebraic equations using Gauss elimination method; Writing ‘m’ files in MATLAB platform to solve non-linear algebraic equations using Newton Raphson Technique; Writing ‘m’ files in MATLAB platform to control level in a tank using P/PI/PID controller; Introduction to ‘Simulink’. Finding out response of a first and second order system (transfer function) using ‘simulink’; Simulation of a stirred tank reactor (both open loop and closed loop) using ‘simulink’.

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<tr>
<td>BM3701</td>
<td>Biomedical Instrumentation Lab</td>
<td>2</td>
<td>K. Pal</td>
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</table>

Monitoring the human body surface temperature using thermistor; To compare the variations in the recovery of the heart rate of an athlete and a sedentary person using a hand-grip heart rate monitor after exercise; To design an algorithm to determine respiration rate of a person using spirometer; To design a LM35 based temperature monitoring system; To study the frequency characteristics of passive and active low-pass filter; To study the frequency characteristics of passive and active high-pass filter; To study the basic principles of pure tone audiometry; To design a MQ-2 based smoke detection system; Realization of half-wave and full-wave rectifier using SPEEDY-33 (microprocessor) as a signal generator; To implement basic programs in ARM Micro-controller; To study the characteristics of an active integrator; To study the characteristics of an active differentiator.

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<tr>
<td>BM3702</td>
<td>Bio Medical Diagnostics Techniques Lab</td>
<td>1</td>
<td>B. P. Nayak</td>
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</table>

Diagnostic microscopy: Learning the method of DC (differential count) of blood cells, evaluation of PBS (peripheral blood smear); Biochemical Analyzer: Learning the principle of semi-automated biochemical analyzer and estimation of blood parameters (glucose, urea and creatinine) in healthy and pathological subjects; Spirometry: Hand on experience with handheld spirometer for FVC (forced vital capacity) measurement and analysis of results; Total abdominal ultrasound: Hands on experience with USG device, different types of probes, demonstration and technical analysis of USG image; X-Ray: Hands on experience with digital X-Ray device, operation and technical analysis of X-ray images of respiratory and musculoskeletal system; CT scanner: Demonstration of 16 slice CT scanner operation and technical analysis of abdominal CT images; MRI scanner: Demonstration of MRI scanner operation and technical analysis of CNS MRI images.

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<tr>
<td>BM3703</td>
<td>Biomaterials Lab</td>
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<td>A. Biswas</td>
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<tr>
<td>BM3704</td>
<td>Microprocessor And Microcontroller Lab</td>
<td>2</td>
<td>K. Pal</td>
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</table>
Familiarization of microprocessor platform (USB-4704, Advantech), Computer based data acquisition using USB-4704, Digital I/O experiments using USB-4704, Familiarization of microcontroller platforms (Arduino UNO, and Arduino Mega), Measurement of the temperature and the humidity using DHT-11 sensor, Designing a high temperature alert system using an LM35 sensor, Designing of an LCD based temperature monitoring system, Designing of a high gas concentration alert system using a gas sensor, Determining Respiration Rate using Vernier Spirometer, and Designing of a wireless data transfer system using ZigBee (IEEE 802.15.4).

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<tr>
<td>BM3705</td>
<td>Biomedical Signal Processing Lab</td>
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</table>

Introduction to Graphical User Interface based programming; Implementing simple mathematical and logical operations on medical signals; Understand the properties of the different loops for the acquisition of medical signals and designing medical devices; Designing programs to generate basic signals (Sine, Square, Triangular); Frequency domain analysis and filtering of the ECG, EOG and EMG signals; Processing of signals as arrays; Manipulation of signals to merge, extract, append and scale two or more dynamic signals; Filter designing from transfer function and pole-zero location; Implementation of filtering techniques for suppression of noise and extraction of features from ECG signals; Designing of heart rate monitor and demand pacemaker; Designing of bio-feedback system.

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<tr>
<td>BM3706</td>
<td>Bioprocess Optimization Lab</td>
<td>3</td>
<td>S. Paul</td>
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</table>

Full factorial designs for measuring all possible interactions, Fractional factorial designs for measuring limited interactions, Analysis of Variance, Generate an experimental design using excel, carry out and analysis of the experimental designs using excel, Generate Central composite designs (CCDs) with the Statistics and Machine Learning Toolbox function, Generate Box-Behnken designs (BBDs) with the Statistics and Machine Learning Toolbox function, Visualize results of experimental designs using Design of Experiments (DOE) plots such as interaction plot, main effects plot, multi variable plots. Demonstration of design expert and xldstat softwares. Demonstration of RSM in matlab.

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<tr>
<td>BM3707</td>
<td>Biochemical Engineering Lab</td>
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<td>K. Pramanik</td>
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<tr>
<td>BM3708</td>
<td>Analytical Techniques in Biotechnology Lab</td>
<td>2</td>
<td>A. Sarkar</td>
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</table>

Introduction to absorption an elimination spectroscopy – UV and visible spectrometers UV visible and absorption method, fluorescence and phosphorescence spectrophotometry Infrared spectrometers, NMR – basic principles – types-spectra and molecular structure- elucidation, quantitative analysis and integration and applications in medicine – mass spectrometry, Circular Dichroism (CD)-Principles, instrumentation and applications, Principle and Operations of Ion Exchange Chromatography, High Performance Liquid Chromatography (HPLC), Gas Liquid Chromatography (GLC), Gel Filtration Chromatography, Affinity Chromatography, Membrane Separation, Ultrafiltration. Study of surfaces, Scanning probe microscopes, TEM, SEM and AFM.
Electrophoresis, Theory of Electrophoresis, Electrophoresis of Protein, PAGE, SDS-PAGE, Agarose Electrophoresis of Nucleic Acid, Isoelectric Focusing of Protein Pulse Gel Electrophoresis and Western Blotting.

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<td>BM3709</td>
<td>Bioprocess Engineering lab</td>
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<tr>
<td>BM3710</td>
<td>Environmental Biotechnology Lab</td>
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<td>P. Balasubramanian</td>
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Water analysis: Determination of pH, electrical conductivity, alkalinity, Hardness, total suspended solids (TSS) and total dissolved solids (TDS) in water samples. Waste water analysis: Determination of dissolved oxygen, biochemical oxygen demand, chemical oxygen demand in wastewater samples. Soil analysis: Determination of organic matter, cation exchange capacity and acidity in soil samples. Air analysis: Determination of carbon monoxide, oxides of Sulphur, oxides of nitrogen in air samples; Isolation of microflora (bacteria, fungi, mold and pollen) from different environmental medium. Biodegradation studies for the removal of toxic pollutants, Biosorption studies for the removal of heavy metals and dyes. Bioleaching studies for the recovery of heavy metals and dyes.

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<td>BM3711</td>
<td>Genetic Engineering Lab</td>
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<td>M. K. Gupta</td>
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<tr>
<td>BM4000</td>
<td>Physiological Modelling</td>
<td>3</td>
<td>S. S. Ray</td>
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Medical Uncertainties, Types of Medical Studies, Data Collection, Nonsampling Errors and Other Biases, Sampling Methods, Sampling Concepts, Common Methods of Random Sampling, Prospective Studies, Retrospective Studies, Cross-Sectional Studies, Comparative Performance of Prospective, Retrospective, and Cross-Sectional Studies, Clinical Trials, Therapeutic Trials, Rates and Ratios, Presentation of Variation by Figures, Graphs for
Frequency Distribution, Pie, Bar, and Line Diagrams, Special Diagrams in Health and Medicine, Charts and Maps, Measurement of Uncertainty: Probability, ROC Curve, Clinimetrics and Evidence-Based Medicine, Measurement of Community Health, Confidence Intervals, Principles of Tests of Significance, and Sample Size, Sampling Distributions, Confidence Intervals, P-Values and Statistical Significance, Assessing Gaussian Pattern, Inference from Proportions, Relative Risk and Odds Ratio, Inference from Means, Student t-Test, ANOVA F-Test, Nonparametric Tests for Location, Linear Regression Models, Some Measuring the Strength of Quantitative Relationship, Nonlinear Regression, Multiple Regression, Logistic, and Proportional Hazards Regression, Analysis of Variance, Control in Physiology and Medicine, Physiological Complexity and the Need for Models; Models and the Modeling Process; Modeling the Data; Modeling the System; Model Identification; Parametric Models – The Identifiability Problem; Parametric Models – The Estimation Problem; Non-parametric Models - Signal Estimation; Model Validation; Basic Models of Physiologic Systems-Compartment Models, Single Compartment Model, Two Compartment Model-a closed system, Two Compartment Model - Open Catenary System, Two compartment Model- Open Mammillary System, Cardiovascular Model and Control, Respiratory Model and Control, Neural Networks for Physiological Control, External Control of Movements, The Fast Eye Movement Control System, Electrical Analogs and State Variable Models of Circuits, Direct Representation of Fluid Circuits

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>BM4001</td>
<td>Medical Embedded Systems</td>
<td>3</td>
<td>K. Pal</td>
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</table>

Introduction to microprocessor (ATmega328) and Arduino software. Programming: Anatomy of program, fundamental of programming concepts, and Arduino development environment.
Embedded systems design: Embedded system design process, preliminary testing, and complete and accurate documentation.
Serial communication subsystem: Serial communications, serial communication terminology, serial USART, system operation and programming, SPI programming, and two-wire serial interface.
Analog to digital conversions: Sampling, Quantization and Encoding, Analog-to-Digital Conversion (ADC) Process, ADC Conversion Technologies, Programming the ADC, One-bit ADC - Threshold Detector, Digital-to-Analog Conversion (DAC).
Interrupt Subsystem: ATmega328 Interrupt System, Interrupt Programming, and Foreground and Background Processing.
Atmel AVR Operating Parameters and Interfacing: Operating Parameters, Battery Operation, Input Devices, Output Devices, DC Solenoid Control, and DC Motor Speed and Direction Control.
Applications of embedded systems in medical industry.

**Essential Reading:**
Supplementary Reading:

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<th>Sub. Code</th>
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<th>Course Caretaker</th>
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<tbody>
<tr>
<td>BM4002</td>
<td>Hospital Management</td>
<td>3</td>
<td>S. S. Ray</td>
</tr>
</tbody>
</table>

Classification of Hospital systems, Role of biomedical engineers; Aspects of hospital services- outpatient- inpatient supportive emergency drug and medical supply nursing dietary service transport services; Hospital planning – location, orientation, budgeting, inside & outside communication, electric power supply for various theatres and rooms, diesel generator, standby power supply; Air-conditioning of important theatres and equipment housings, water supply requirements and management, lifts, fire fighting equipments; Sanitation, laundry services; Computer and information management in hospitals: computer aided hospital management: application administration / discharge records of patient’s patients billing – maintenance of patient’s records, their history, maintenance of inventory of medicines and drugs- purchase; Electrical factors in hospital design, voltage stabilizer, uninterrupted powersupply for intensive care units and computerized monitoring units-safety precautions, protection, grounding of ECG, EEG, ENG and other therapeutic equipments; Biomedical equipment services their purchase, servicing and maintenance of equipment, training of men for medical equipments, preventive and periodical maintenance procedure.

Essential Reading:

Supplementary Reading:

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<tbody>
<tr>
<td>BM4003</td>
<td>Metabolic Engineering</td>
<td>3</td>
<td>A. Sarkar</td>
</tr>
</tbody>
</table>

Basic concepts of Metabolic Engineering, Overview of cellular metabolism, Different models for cellular reactions, Methods for metabolic characterization: genome, transcriptome, proteome, metabolome, fluxome; Comprehensive models for cellular reactions; Coordination of metabolic reactions: Feedback inhibition, Energy charge, Multigene networks, Metabolic regulation network at enzyme level and whole cell level, Examples of metabolic pathway manipulations, Metabolic pathway synthesis algorithms, Metabolic flux analysis and its applications, Methods for experimental determination of metabolic fluxes, Metabolite Balancing, Tracer Experiments, MS and NMR in labelling measurement, Analysis of Metabolic control analysis (MCA), Determination of Flux control coefficients, MCA of Linear and Branched pathways, Thermodynamics of cellular processes, Metabolic design: Gene amplification, Gene-disruption, Randomized and targeted strain development, New concepts for quantitative bioprocess research and development.

Essential Reading:
**Supplementary Reading:**


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<tbody>
<tr>
<td>BM4004</td>
<td>Computer Aided Drug Design</td>
<td>3</td>
<td>M. K. Gupta</td>
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**Essential Reading:**


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<tr>
<td>BM4005</td>
<td>Pharmaceutical Biotechnology</td>
<td>3</td>
<td>K. Pal</td>
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</tbody>
</table>

Pharmaceuticals, biologics and biopharmaceuticals, Protein structure, Gene manipulation and recombinant DNA technology, The drug development process, Sources and upstream processing, Downstream processing, Product analysis, The cytokines: The interferon family, Cytokines: Interleukins and tumour necrosis factor, Growth factors, Therapeutic hormones, Recombinant blood products and therapeutic enzymes, Antibodies, vaccines and adjuvants, and Nucleic acid- and cell-based therapeutics.

**Essential Reading:**


**Supplementary Reading:**


BM4100  Structural Biology  3  S. Paul


Essential Readings:

Supplementary Reading:

BM4102  System Biology  3  N. Sarkar

Introduction to cellular and population-level systems biology with an emphasis on synthetic biology, modeling of genetic networks, cell-cell interactions, and evolutionary dynamics; Molecules of life: Genes and proteins; Transcription networks; Regulation of gene transcription; Network motifs in transcription regulation; Network motifs in signaling networks; Origins of biological robustness; Optimal gene circuits; Kinetic modeling of biochemical reactions; Kinetic modeling of large scale biomolecular networks; Integration of regulatory and metabolic networks; Biological networks and drug development.

Essential Reading:

Supplementary Reading:

BM4200  Tissue Engineering  3  D. Verma

Introduction to mammalian cell & tissue engineering for human therapeutic applications. Cell adhesion and cell migration, extracellular matrix, cell aggregates, designing scaffolds, fabrication of scaffolds, cell-materials interactions, growth factors and their role in tissue genesis, delivery of growth factors, types of bioreactors used for tissue engineering, design & production of functional tissue units, Clinical applications & regulatory issues.

Essential Reading:

Supplementary Reading:
Surface dependent engineering properties, Cells and tissue interaction with surface, Common surface initiated engineering failures, Corrosion and wear of implants, Importance and necessity of surface engineering.

Classification of surface engineering techniques: Mechanical, Physical and Chemical methods.


Application surface modification and coatings: Functionalisation of implant surface, Biocompatible coating for metallic biomaterials, Coating for osseointegration of metallic biomaterials, Antibacterial coating for metallic biomaterials, Polymer based degradable coatings for metallic biomaterials.

**Essential Reading:**

**Supplementary Reading:**
Introduction to downstream processing, principles, characteristics of biomolecules and bioprocesses. Pretreatment and stabilisation of bioproducts. Unit operations for solid-liquid separation insoluble products: Centrifugation and Filtration: basic principles, design characteristics; Ultracentrifuges: principles and applications; Sedimentation; Flocculation; Cell disruption: Sonication; Bead mills; Homogenizers; Chemical lysis; Enzymatic lysis; Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, Precipitation of proteins by different methods: salting in and salting out method, Adsorption. Membrane based purification: Ultrafiltration and Microfiltration; Reverse osmosis; Dialysis. Chromatography: principles, instruments and practice, adsorption, reverse phase, ion-exchange, size exclusion, hydrophobic interaction, bioaffinity and pseudo affinity chromatographic techniques. Electrophoresis. Final step: Drying, lyophilisation and crystallization in final product formulation.

Essential Reading:
2. M. L. Shuler and F. Kargi; Bioprocess Engineering Basic concepts.

Supplementary Reading:

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<tr>
<td>BM4302</td>
<td>Bioseperation Techniques</td>
<td>3</td>
<td>I. Banerjee</td>
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</tbody>
</table>

Basic concepts of bio-separation process, Filtration: Filtration at constant pressure and at constant rate, batch and continuous filtration, centrifugal and cross-flow filtration, Centrifugation: principles and design parameters, Ultra centrifugation, Liquid-liquid extraction, Precipitation: Salting out and solvent precipitation, Chromatographic separation: size exclusion chromatography, ion exchange chromatography, affinity chromatography, Paper chromatography, thin layer chromatography, high performance liquid chromatography (HPLC), 1D and 2D Electrophoresis, Micro-filtration, Osmosis and reverse osmosis, Dialysis, Distillation, Crystallization.

Essential Reading:

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<tr>
<td>BM4303</td>
<td>Bioinformatics</td>
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<td>M. K. Gupta</td>
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</table>

Scope of bioinformatics, Major bioinformatics resources (NCBI, EBI, ExPASy), Sequence and structure databases, Data Mining, Understanding large scale DNA and protein sequencing and arrays, Sequence analysis, biomolecular sequence file formats, scoring matrices (PAM and BLOSUM), sequence alignment, gene prediction, phylogeny, knowledge discovery in biochemical databases, Molecular modelling and simulations.

Essential Reading:
Supplementary Reading

1. Mount DW, Bioinformatics: Sequence and Genome Analysis by Cold Spring Harbor Laboratory Press.

2. Attwood T and Parry-Smith D, Introduction to Bioinformatics, Prentice Hall.

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<td>BM4400</td>
<td>Plant Secondary Metabolites</td>
<td>3</td>
<td>A Sarkar</td>
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</table>

Introduction to plant secondary metabolites; Definition and systematic of secondary metabolites, structures, functions and commercial significance of secondary metabolites: alkaloids, terpenoids/isoprenoids, flavonoids and phenolics; Secondary metabolites in chemical defense of plants, ecological functions, and biological activities; Important pathway leading to the biosynthesis of secondary metabolites (e.g. serpentine, shikonin, diosgenin and cardenolids) in plants; Metabolic products produced by in vitro culturing of plant cells, selection of plant cells/tissues for the production of a specific product, Culture system in secondary plant product biosynthesis-batch continuous cultures and immobilized plant cells, Biotransformation of precursors by cell culturing, Production of secondary plant metabolites from higher plants: Tissue cultures, organ cultures, hairy root cultures. Bioreactors: scaling up of production of secondary metabolites Extraction and analytical methods for the above metabolites, Regulation: metabolic channeling, compartmentalization, cross-talk/exchange of intermediates between biochemical pathways, Application of specific enzyme inhibitors, Precursor feeding, genetic regulation of key enzymes, developmental, seasonal and environmental factors. Industries involved in the production of plant secondary metabolites, Potential and future prospect of the secondary metabolites production by plant cells culture techniques

Essential Reading:


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<tr>
<td>BM4401</td>
<td>Plant Biotechnology</td>
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<td>A Sarkar</td>
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</table>

Special features and organization of plant cells; Concept of cellular totipotency: Nutritional requirements, single cell culture, micro-propagation, somaclonal variation, somatic embryogenesis and production of embryoids; Protoplast isolation and culture; Somatic hybridization and cybrid production and their applications in crop improvement. Productions of virus free plants using meristem culture. Regeneration of plants; Basis of tumor formation, hairy roots, features of Ti and Ri plasmids, mechanisms of DNA transfer, role of virulence genes, use of Ti and Ri as vectors, binary vectors, use of 35S and other promoters, genetic markers, use of reporter genes, methods of nuclear transfer, particle bombardment, electroporation, microinjection, transformation of monocots; Transgene stability and gene silencing. Herbicide and insect resistance; Plant Genetic Engineering: Transgenic plants, Genetically modified (GM) plants; Plant products of industrial importance; Biochemistry of major metabolic pathways and products; Autotrophic and heterotrophic growth; Plant growth regulators and elicitors; Cell suspension culture development: methodology, kinetics of growth and production formation, nutrient optimization; Production of secondary metabolites by plant suspension cultures; Hairy root cultures and their cultivation, Techniques in raising transgenics, Applications of Plant Biotechnology in Crop Improvement.
Essential readings:

Supplementary Reading:

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<tbody>
<tr>
<td>BM4403</td>
<td>Solid And Hazardous Waste Management</td>
<td>3</td>
<td>P. Balasubramanian</td>
</tr>
</tbody>
</table>

Types and Sources of solid and hazardous wastes, need for waste management, salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, nuclear wastes, lead acid batteries, electronic wastes, plastics and fly ash. Composition - physical, chemical and biological properties of solid wastes, Hazardous characteristics – TCLP tests. Biological and chemical conversion technologies, methods and controls of composting, thermal conversion technologies and energy recovery, incineration, solidification and stabilization of hazardous wastes, treatment of biomedical wastes. Disposal in landfills, Landfill classification, types and methods, site selection, design and operation of sanitary landfills, secure landfills and landfill bioreactors. Waste minimization and concept of industrial ecology and industrial symbiosis.

Essential Reading:

Suggested Reading:

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<tr>
<td>BM4405</td>
<td>Bioenergy And Biofuels Engineering</td>
<td>3</td>
<td>K. Pramanik</td>
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</table>


Essential Reading:
Introduction to plant tissue culture, advantages of cell, tissue and organ culture as source of secondary metabolites; hairy root cultures; screening of high yielding cell lines; procedures for extraction of high value industrial products, fractionation, bioassays; growth and production kinetics of cell cultures in shake flasks; scale-up procedures in bioreactors, types of bioreactors for plant cell cultures; Manipulation in production profile by biotic and abiotic elicitation; biotransformation, lab facilities and operations, tissue culture media: preparation and handling, establishing aseptic cultures; Micropropagation via axillary and adventitious shoot proliferation; Somatic embryogenesis; production of artificial seeds; Double haploid production by androgenesis and gynogenesis; triploid production by endosperm culture; production of virus free plants by meristem, shoot-tip culture; Cell Suspension cultures; protoplast isolation and regeneration, somatic hybridization and cybridization; protoclonal, somaclonal and gametoclonal variation for crop improvement; Cryopreservation. Genetic material of plant cells with an introduction to chloroplast and mitochondrial DNA; Restriction enzymes; Transformation of plant cells; different type of vectors including viral vectors and their benefits; Modes of gene delivery in plants: Particle bombardment, electroproporation, microinjection; *Agrobacterium* mediated gene transfer, Ti and Ri plasmids; Screening and selection of transformants, PCR and hybridization methods; Transgene selection and silencing; Generation and maintenance of transgenic plants, Bt cotton, golden rice and some others as examples; Aims and scope, bottlenecks; production of industrial enzymes, biodegradable plastics, polyhydroxybutyrate, antibodies, edible vaccines; manipulation of metabolic pathways for production of fatty acids, industrial oils, terpenoids, flavanoids etc.

**Essential Reading:**

**Supplementary Reading:**


**Essential Reading**

**Supplementary Reading**
Introduction, Heuristic search techniques, Game playing, Knowledge representation, Knowledge representation structures, Reasoning, Learning, Association learning, Clustering, Reinforcement learning, Statistical learning, Artificial neural nets, Supervised learning, Unsupervised learning, Expert systems

**Essential Reading:**

**Supplementary Reading:**

Brief introduction to medical imaging techniques: X-ray, CT scan, PET scan, SPECT scan, MRI scan, and Ultrasound imaging.

Digital image fundamentals: Image digitization, sampling & quantization, Different types of transform- Discrete Fourier Transform, Fast Fourier Transform, and 2-D Fourier and inverse Fourier Transform.

Image enhancement fundamentals: Spatial and frequency domain methods, contrast enhancement, histogram processing, image smoothing, image averaging, masking, image sharpening, and enhancement in the frequency domain.

Image restoration fundamentals: Degradation model, discrete formulation, and algebraic approach to restoration–unconstrained and constrained.

Image compression and segmentation fundamentals: Image compression models, and lossy and lossless compression techniques.

Image segmentation: point detection, line detection, edge detection, edge linking and boundary detection.

Algorithms used in medical image processing.

**Essential Reading:**


**Supplementary Reading:**

Lasers in surgery: Surgical instrumentation of CO2, Ruby, Nd-YAG, He-Ne, Argon ion, Q-switched operations, continuous wave, Quasi–continuous, surgical applications of these lasers. Laser applications in medicine: Lasers in dermatology, lasers in ophthalmology, laser photo coagulations, laser in dentistry, Laser flow cytometry, Laser transillumination and diaphanography- Speckle intereferometry, holography- Application Safety with biomedical Lasers.
Fiber optics in diagnosis: Transmission of signals, light, and construction details of optical fiber, application of fiber optics in medical field.

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<tr>
<td>BM4603</td>
<td>Measurements, Sensors And Transducers</td>
<td>3</td>
<td>K. Pal</td>
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</table>

Measurements: SI units, systematic and random errors in measurement, expression of uncertainty – accuracy and precision index, propagation of errors. PMMC, MI and dynamometer type instruments; dc potentiometer; bridges for measurement of R, L and C, Q-meter. Measurement of voltage, current and power in single and three phase circuits; ac and dc current probes; true rms meters, voltage and current scaling, instrument transformers, timer/counter, time, phase and frequency measurements, digital voltmeter, digital multimeter; oscilloscope, shielding and grounding.
Sensors and Transducers: Resistive-, capacitive-, inductive-, piezoelectric-, Hall effect sensors and associated signal conditioning circuits; transducers for industrial instrumentation: displacement (linear and angular), velocity, acceleration, force, torque, vibration, shock, pressure (including low pressure), flow (differential pressure, variable area, electromagnetic, ultrasonic, turbine and open channel flow meters) temperature (thermocouple, bolometer, RTD (3/4 wire), thermistor, pyrometer and semiconductor); liquid level, pH, conductivity and viscosity measurement.

Essential Reading:

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<tbody>
<tr>
<td>BM4605</td>
<td>Rehabilitation Engineering And Robotics</td>
<td>3</td>
<td>K. Pal</td>
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Essential Reading:

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<tr>
<td>BM4607</td>
<td>Communication and Telemedicine</td>
<td>3</td>
<td>K. Pal</td>
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</table>

Communication: Amplitude- and frequency modulation and demodulation; Shannon’s sampling theorem, pulse code modulation; frequency and time division multiplexing, amplitude-, phase-, frequency-, pulse shift keying for digital modulation.


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<tr>
<td>BM4700</td>
<td>Tissue Engineering Lab</td>
<td>1</td>
<td>D. Verma</td>
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</tbody>
</table>

Scaffold Fabrication and Characterization: Preparation of 2D polymer Films; Preparation of 3D porous scaffold by Salt Leaching Method; Preparation of 3D porous scaffold by Freeze Drying method; Preparation of 3D porous scaffold by freeze gelation method; Preparation of nanofibrous scaffold by Electrospinning method; Characterization of scaffold: pore size & porosity and mechanical Strength; contact angle measurement; swelling behavior; Culture of MSCs, Cell counting & cell morphology; Seeding of MSCs on scaffolds; MTT Viability Test; Differentiation of MSCs into bone cells in the scaffold; Characterization of tissue engineered bone.

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<tr>
<td>BM4701</td>
<td>Health Informatics And Telemedicine Lab</td>
<td>2</td>
<td>S. S. Ray</td>
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</table>
Introduction to MIT app inventor, Training on Development of applications for mobile devices, Database management for health informatics, Exploration of different sensors and its utility in mobile devices, Data security in health informatics, Data compression methods in telemedicine, Operation of Medical devices through mobile devices.

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<tr>
<td>BM4702</td>
<td>Computational Methods In Bioengineering Lab</td>
<td>2</td>
<td>A. Thirugnanam</td>
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<tr>
<td>BM4703</td>
<td>Medical Imaging And Image Processing Lab</td>
<td>2</td>
<td>K. Pal</td>
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</table>

Image enhancement–Histogram; Image smoothing, Image sharpening; Low-pass filter, high-pass filter, median-filter; Point-detection, Line-detection; Edge detection, Prewitt Edge, Edge-detector; Mathematical operation on images; Image data compression; Implementation of the TWO Dimensional F.F.T.; Batch processing of manufactured medical devices; Continuous monitoring of the manufactured medical devices; Particle size analysis; Image registration; Volume reconstruction; Determination of the color-coded parts in a given device; Inspection of devices using gauging; Cell culture analysis; Inspection of the PCB components; Edge detection as a tool for connector pin inspection; Inspection of the blister packs; Dental floss inspection; Pills inspection using watershed algorithm; Tablet discoloration inspection; Foreign tablet inspection; Label Inspection.

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<tr>
<td>BM4704</td>
<td>Soft computing Lab</td>
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<td>A. Thirugnanam</td>
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</table>

**C Programming:** Introduction, declaring variables, arithmetic operations, relational operators, For and While loops, switch/case, if, if else statement, strings, Arrays, Functions, structures, Pointers, system calls. Simple programs to illustrate the above topics.

**C++ Programming:** Principles of object-oriented Programming, Basic concept of object-oriented Programming, Benefits of OOP, Difference between object oriented language and procedure oriented language II Introduction of C++, Class, Objects, Creating Simple program using class and object III Token expression and control structure IV Classes and object in detail, Declaring class and defining member function, making outside function inline, Nesting member function, Private member function arrays within a class, memory allocation of objects, Static data members and Member functions, Arrays of Objects, Object as a function argument, Friend functions, Returning objects, const. member functions.

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<td>BM4705</td>
<td>Bioinformatics Lab</td>
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<td>M. K. Gupta</td>
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</table>

Data retrieval from biological databases: MapViewer, ENSEMBLE, OMIM, SNP databases. Retrieval of nucleic acid and protein sequence from biological database (GenBank, EMBL, Uniprot) and their interpretation. Retrieval of protein structure from PDB database and viewing in RASMOL. Nucleic acid and protein sequence analysis (BLAST, EMBOSS). Multiple sequence alignment (CLUSTAL, EMBOSS). Phylogenetic analysis (PHYLLIP). ORF
identification, in silico translation and Gene prediction (GeneMark). Secondary structure prediction in nucleic acids (MFOLD) and proteins (Chou-Fasman and GOR methods). Molecular Modelling of tertiary structure of protein (SWISS MODEL, MODELLER). Identifying protein folding (PHYRE). Functional annotation of genes and proteins (GO, DAVID)

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<tr>
<td>BM4706</td>
<td>Enzymology and Protein Engineering Lab</td>
<td>2</td>
<td>N. Sarkar</td>
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Determination of Km and Vmax of an enzymatic reaction; Effects of pH on enzymatic rate; Effects of temperature on enzymatic rates; Effects of substrate concentration on enzymatic rates; ELISA; Monitoring protein stability through equilibrium unfolding method; Effects of pH on protein unfolding; Effects of temperature on protein unfolding; Monitoring protein folding/unfolding kinetics using stopped flow apparatus; Structural characterization of proteins using various biophysical methods.

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<td>BM4707</td>
<td>Plant Biotechnology Lab</td>
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<td>N. Patra</td>
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</table>

Tissue culture media preparation; Callus induction; Hairy root induction; Plant genomic DNA isolation; RNA isolation; Reverse transcriptase PCR; Genetic transformation of plants; effect of cultivation conditions, Elicitation of secondary metabolites; Permeabilization; In-situ product extraction; Immobilization of plant cells; Scale-up of plant cell cultivation in a bioreactor.

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<tr>
<td>BM4708</td>
<td>Food And Fermentation Technology Lab</td>
<td>1</td>
<td>A. Sarkar</td>
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</table>

Isolation of lactic acid bacteria from yoghurt, Estimation of solubility, specific gravity, and Refractive Index of food material, To study the spreading coefficient of butter, stored at different temperatures, To determine the puncture strength of fruits and vegetables, To study the effects of Variations in Gelatin Concentration, pH, Sucrose Concentration, and Presence of a Proteolytic Enzyme on Gelatin Gel Strength. To study the extrusion properties of dough, To study the cutting strength of fruits and vegetables. To study the quantity and coagulation of protein in food, To determine the moisture content within food materials; To study the viscosity of the commonly available sauces and ketchups, To study the Enzymatic Browning of food mat, Production of vitamins, amino acids, organic acids, enzymes and antibiotics, alcohols using aerobic/anaerobic fermentation process.

**Essential readings:**

**Supplementary readings:**

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<tr>
<td>BM4709</td>
<td>Downstream processing and Bioseparation Lab</td>
<td>3</td>
<td>K. Dutta</td>
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</table>

Separation of proteins from mixture using ammonium sulphate precipitation method, separation of biomolecules using dialysis, determination of filtration efficiency of a filter press, separation of carbohydrates from non-fat powdered milk, separation of phenolic bioactive compounds using silica-gel column chromatography, separation of amino acids using thin-layer chromatography, isolation of ethanol from fermentation broth using distillation, separation of
proteins using SDS-PAGE gel electrophoresis, determination of void volumes of gel filtration column, fractionation of mixture of carbohydrates using gel filtration chromatography, extraction of glycoproteins from bacterial cell lysate by affinity chromatography.

### Homology modelling of protein

### Solid works
Introduction to Solid works: Development of simple models (bioimplants, bone, etc) using solidworks, Part modelling and part assembly, modification of dimensions in solid works.

### ANSYS
Introduction to ANSYS, development of 2D and 3D models using ANSYS by keypoints, lines, etc, model importing in ANSYS, meshing and boundary conditions, FEA analysis of models using ANSYS (static, dynamic, transient, thermal, fluid flow, etc) in Bioengineering.

### Matlab Programming For Bioengineering
Introduction to MATLAB, Constants, variable, and expressions, Vectors and matrices, Polynomials, Input-Output statements, MATLAB graphics, Control structures, Simulink basics, MATLAB applications in control systems, MATLAB applications in neural networks, MATLAB applications in fuzzy logic systems, MATLAB applications in biosignal analysis.

### Department of Civil Engineering

#### Sub Discipline: Non Specific Subjects

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<th>Sub Code</th>
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<tbody>
<tr>
<td>CE 1000</td>
<td>Engineering Mechanics</td>
<td>3-1-0</td>
<td>4</td>
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<tr>
<td>CE 2001</td>
<td>Civil Engineering Materials and Construction</td>
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<td>CE 3703</td>
<td>Fluid Mechanics &amp; Hydraulic Machines Laboratory</td>
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<td>CE 3704</td>
<td>Structural Engineering Laboratory</td>
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<td>CE 3705</td>
<td>Geotechnical Engineering Laboratory</td>
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<td>CE 4001</td>
<td>Estimation &amp; Construction Management</td>
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<td>CE 4101</td>
<td>Ground Improvement Techniques</td>
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<td>CE 4103</td>
<td>Advanced Foundation Engineering</td>
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<td>CE 4106</td>
<td>Soil Structure Interaction</td>
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<td>CE 4203</td>
<td>Advanced Design of Reinforced Concrete Structures</td>
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<td>CE 4205</td>
<td>Advanced Mechanics of Solids</td>
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<td>CE 4206</td>
<td>Design of Industrial Steel Structures</td>
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<td>CE 4301</td>
<td>Advanced Transportation Engineering</td>
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<tr>
<td>CE 4302</td>
<td>Traffic Engineering &amp; Transportation Planning</td>
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<td>Pavement Design</td>
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<td>Pavement Materials</td>
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<td>CE 4305</td>
<td>Planning and Design of Airports</td>
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<td>CE 4306</td>
<td>Railway and Tunnel Engineering</td>
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<td>Computational Fluid Dynamics</td>
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<td>Engineering Hydrology</td>
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<td>CE 4406</td>
<td>Water Resources Planning and Management</td>
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<td>CE 4502</td>
<td>Advanced Environmental Engineering</td>
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<td>CE 4503</td>
<td>Environmental Impact Assessment</td>
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<td>CE 4504</td>
<td>Air Quality Management</td>
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<td>CE 4505</td>
<td>Environmental Management in Industry</td>
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<td>CE 4701</td>
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<td>CE 4702</td>
<td>Water resources Engineering Design Practice</td>
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<td>CE 4703</td>
<td>Steel Structures Design Practice</td>
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<td>CE 4704</td>
<td>Transportation Engineering Design Practice</td>
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<td>CE 4705</td>
<td>Environmental Engineering Design Practice</td>
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<tr>
<td>CE 4706</td>
<td>Computer Aided Design Practice</td>
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Note: For 6 level courses please refer to M. Tech. Curriculum and Syllabi.
CE 1000  ENGINEERING MECHANICS  4 Credits [3-1-0]
Statics: Introduction: Basic Concepts of Force, Moment and Couple; Equilibrium of Coplanar force systems; Friction, Belt friction and Screw Jack; Internal forces in Members of Trusses and (Method of joints, Method of Sections) and Analysis of Frames (Method of Members); Properties of Surfaces: Centroid and Moment of Inertia of plane figures, Principle of Virtual Work and application;

Essential Reading:

Supplementary Reading:

CE 1500  ENVIRONMENT AND SAFETY ENGINEERING  3 Credits [3-0-0]
Environmental Engineering: Introduction to Environmental engineering Nature and scope of environment problems; Ecosystem; Local, regional and global environmental challenges, Basic concepts of biodiversity and its significance.
Water Pollution: Fundamentals and Control Strategies: Water quality-physical, chemical & biological characteristics, Drinking water standards; Effluent quality requirements; Water and wastewater treatment processes-treatment train, physical, chemical and biological unit operations.
Air Pollution: Fundamentals and Control Strategies; Air pollution - sources, classifications and regulations; and their effects, Monitoring Principles and instrumentation for particulate and gaseous pollutant measurements; Air pollution control strategies: physical, chemical and biological methods.
Noise standards and criteria, Noise pollution measurement in ambient air and industrial complex, Control methods for noise pollution; Engineering principles in waste management, Case studies on industrial applications of cleaner technologies in industries.
Workplace Accidents and Safety: Accident Causation Theories (Domino Theory, Human Factor Theory), Accident Investigation and Reporting, Legal Aspects of Safety: Factories Act 1948, Other International Codes (OSHA Laws & Regulations).
**Essential Reading:**

**Supplementary Reading:**

**CE 1701 ENGINEERING DRAWING**
2 Credits [0-0-3]

**Essential Reading:**

**Supplementary Reading:**

**CE 2001 CIVIL ENGINEERING MATERIALS AND CONSTRUCTION**
3 Credits [3-0-0]
General civil engineering material performance requirements: strength, stiffness, durability, appearance. Concrete: properties of fresh and hardened concrete, reinforcement, concrete mix design. Steel: properties of steel, steel grades, protection from corrosion and fire. Pavement materials: production, testing and applications. Geosynthetics: overview of available materials, geotextile functions and mechanisms. Timber. Masonry. Building construction: Foundations – Shallow and Deep foundations; Stone and Brick Masonry; Reinforced concrete and reinforced brick work; Setting and laying out a building; Damp proofing of floors and walls; Doors and Windows; Staircase and escalators; Scaffolding and Formwork.

**Essential Reading:**

**Supplementary Reading:**
CE 2002 ELEMENTS OF CIVIL ENGINEERING 3 Credits [3-0-0]
Building materials and construction materials: Bricks, Stones, Cement, Cement mortar, Cement Concrete, Reinforced concrete, pre stressed concrete; Construction: Foundations, Brick masonry, Stone masonry, walls, columns, floors, steps& stairs, lintels, roofs, doors& windows; Surveying: Chain Surveying, Compass surveying, Plane Table Surveying, Leveling. Transportation Engineering: Classification of highways, principles of alignment, Types of pavements, geometric design of airport components; Floods: River systems and Flood forecasting.

Essential Reading:

Supplementary Reading:
2. S. C. Rangawala, Building Construction, Charotar Publishing House
3. S. P. Bindra, A Course in Highway Engg, Dhanpat Rai Publication

CE 2003 MECHANICS OF SOLIDS 3 Credits [3-0-0]
Concept of Stress and strain, Definition of stress, stress tensor, normal and shearing stresses in axially loaded members, stress-strain relationship; Generalized Hooke’s Law, Poisson’s ratio, relationship between E, G, K and ν, stress-strain diagram for uniaxial loading, working stress.; Analysis of Axially Loaded Members, Composite bars in tension and Compression, temperature stresses in composite rods, statically indeterminate problems, Transformation of Plane stress and Plane strain, principal stresses and principal planes, Mohr’s circle of stress, principal strains and principal axes of strain, Mohr’s circle for strain, Strain rosettes, determination of principal strains from strain measurements, calculation of principal stresses from principal strains; Stresses in thin cylinders and thin spherical shells, wire winding of thin cylinders; Torsion of Circular shafts and Helical Springs, strength of solid and hollow circular shafts, design of circular members in torsion, close coiled helical springs; Members subjected to flexural loads, shear force and bending moment diagrams for cantilever and simply supported beams, elastic curve.; Theory of simple bending, bending stresses in beams, shearing stresses in beams, composite beams, Slope and deflection of beams by integration method and moment area method; Euler’s theory for compression members; short struts with eccentric loading, Kern of rectangular and circular sections.

Essential Reading:

Supplementary Reading:
1. G. H. Ryder, Strength of Materials, ELBS.

CE 2005 SURVEYING 3 Credits [3-0-0]
Introduction: classification of surveys; Linear measurements: Types of Chains and tapes, chaining and ranging, principles of chain survey, equipments, applications, errors and corrections, obstacles in chaining, - Electronic Distance Measurement (EDM); Angle and direction measurements: Measurement of bearing, Computation of angles from - Bearings, Designation of bearings, fore bearing and back bearing, Prismatic compass, Principles of compass survey, local attraction and corrections, compass traverse and adjustments ; Plane table survey: Equipments, working operations, different methods, advantages and disadvantages, Two point and Three point problems; Levelling: Principle, Levelling instruments, Dumpy level, booking and reducing levels, simple and differential levelling, profile and reciprocal levelling, methods of levelling, curvature and refraction corrections, bubble tube and its sensitiveness, levelling difficulties. Contouring: definition, contour interval, characteristics of contours, direct and indirect methods of contouring, interpolation of contours, uses of contour maps; Minor instruments: box sexant, planimeter, pentagraph, inclinometer

Essential Reading:
1. S. K. Roy, Fundamentals of Surveying, PHI.

Supplementary Reading:
2. D. Clark, Plane and Geodetic Surveying, Constable Company Ltd, 10 Orange Street, London WC.

CE 2102 MECHANICS OF SOIL 3 Credits [3-0-0]
Soil Properties and Classification: Formation of soils and types, Soil as three phase system. Soil consistency, sensitivity and thixotropy; Classification of soil; Soil Compaction: Principles, water content - dry unit weight relationships, optimum moisture content, maximum dry unit weight, factors affecting compaction. Effects of compaction on density, shear strength and permeability. Field compaction methods; Permeability: Soil - water systems - capillarity, flow, Darcy’s law, permeability and tests for its determination, Permeability of stratified soils, estimation of permeability in the field, piping, quicksand condition, seepage, flow nets.  ; Shear Strength of Soil: Coulomb’s law, Mohr’s stress circle, strength envelop and failure conditions. Direct and triaxial shear tests and unconfined compression tests, Effect of pore pressure; Soil exploration: Boring, Sampling, SPT and related corrections, stability of slopes.

Essential Reading:

Supplementary Reading:
1. V. N. S. Murthy, Principles of Soil Mechanics and Foundation Engg, UBSPD.

CE 2201 CONCRETE TECHNOLOGY 3 Credits [3-0-0]
Concrete: Constituent materials; Properties of Cements, aggregates, water, admixtures (chemical and mineral). Mineral admixtures- Silica fumes, fly ash, slag. Mix Design of Concrete ; Properties of Fresh concrete- workability, compaction, curing, Hardened concrete-Compressive strength, split tensile strength, flexural strength; Elasticity, shrinkage and creep. ; Durability of concrete, permeability; corrosion. ; Special concrete- high strength concrete, high performance concrete, self-compacting concrete, ready mix concrete; Form work for concrete;
Concrete under special conditions - Corrosion resistant concrete, lightweight concrete, high density concrete, Concrete for seismic resistant structure.; Precast concrete blocks; Non-destructive testing methods - Ultrasonic pulse velocity, rebound hammer; Repair and Rehabilitation of concrete; fibre reinforced concrete, polymer modified concrete.

**Essential Reading:**

**Supplementary Reading:**

**CE 2202 STRUCTURAL ANALYSIS**

3 Credits [3-0-0]
Concept of determinate and indeterminate structures, determination of degree of indeterminacy in plane frame and continuous structures, determination of member forces in statically determinate pin-jointed space frames, deflection of pin-jointed plane trusses by Williot Mohr diagram; Rolling loads and influence line diagrams for simply supported beams, influence line for forces in members of Pratt and Warren trusses with parallel top and bottom chords; Analysis of fixed and continuous beams by Moment-Area method, Conjugate beam method and theorem of three moments, Analysis of three-hinged and two-hinged arches, Spandrel braced arches; Analysis of suspension cable bridges with three-hinged and two-hinged stiffening girders subjected to dead and live loads, influence line for horizontal thrust, bending moment, normal thrust and radial shear for arches and suspension bridges. Development of generalized slope deflection equations and its applications to beams and plane frames, Moment distribution method and its applications to continuous beams and plane frames including sway and inclined members.

**Essential Reading:**

**Supplementary Reading:**

**CE 2302 TRANSPORTATION ENGINEERING**

3 Credits [3-0-0]
Roadways: Introduction, Road Development plans and programmes; Surveys: Location surveys - Principles of alignment; Geometric design: Cross-sectional elements, Sight distance, Horizontal and vertical alignments, Pavement materials: Subgrade soil, Aggregates, Bituminous binders, Bituminous paving mixes; Flexible pavements design; Rigid pavement design; Drainage, evaluation and maintenance of highways; Traffic Engineering: Speed, Volume, Density, Relation among fundamental parameters, Traffic data collection, Capacity and level of service, Traffic control devices, Road markings, Parking, Roundabout and signalized intersection design; Bridges: Classification of bridges, Investigations and data collection for location of bridge site, Calculation of runoff under bridges, Determination of water way, Economic span, Bridge foundations, Piers and abutments, Superstructures, Loadings, Erection of bridge spans, Temporary bridges and causeways.

**Essential Reading:**

**Supplementary Reading:**

**CE 2402 FLUID MECHANICS**
3 Credits [3-0-0]

Physical properties of fluids- Compressibility, Elasticity, and Viscosity, Ideal and Real fluids, Concepts of shear stress, Newtonian and Non-Newtonian fluids. ; Pressure-density-height relationships, Pressure on plane and curved surfaces, Buoyancy, Stability of immersed and floating bodies, Free and forced vortex; Steady and unsteady, Uniform and non-uniform, Laminar and Turbulent flows, Free surface flows and Enclosed flows, ; Definition of one, two and three-dimensional flows, Velocity and Accelerations, Stream lines, Streak lines and Path lines, Stream tubes, Stream function and Velocity potential, flows nets, Circulation and Vorticity. Equation of continuity, One-dimensional Euler’s equation of motion and its integration to obtain Bernoulli’s equation, Momentum equation; Hydraulic mean radius, Concept of friction loss, Darcy-Weisbach equation Minor losses in pipe, Branched pipes in parallel and series, Transmission of power, Water hammer in pipes, Laminar flow in pipes-Hazen-Poiseulli’s equation, Turbulent flow in pipes, Velocity distribution in pipes, Moody’s diagram; Boundary layer thickness, Energy thickness, Laminar and turbulent boundary layer, separation of Boundary Layer. Momentum integral equation; Drag and Lift coefficient, Pressure drag and Friction drag characteristics on Sphere, Cylinder, and Disc, Circulation, Lift and Magnus effect, Lift Characteristics of air foils, Induced drag ; Open channel flow, Uniform flow, Chezy’s, Kutter’s and Manning’s equation, Concept of specific energy, Critical flow, Point gauge, Pitot tube, Current meter, Venturi meter, Orifice meter, Orifices and Mouth pieces, Notches and Weirs.

**Essential Reading:**

**Supplementary Reading:**
Close coiled helical spring; Beam deflection; Brinell Hardness Test; Rockwell Hardness Test; Torsion Test on mild steel specimen; Tension test on mild steel specimen; Fatigue Test and determination of endurance limit; Column test; Compression testing; Experiments on strain measurement; Plane stress and plane strain; Charpy Impact Test.

**CE 2702 BUILDING DRAWING PRACTICE**
1 Credit [0-0-2]
Basic concept, purpose, function and types of building (Residential, Industrial and Institutional); Principles of site selection, orientation of buildings and distribution of space; Line plan. Development of plan from a line plan; Details of Doors, windows, foundation and stair case etc.; A simple two-roomed official building, multi-storeyed residential building plan, front and sectional elevations. Building drawing project.

**Essential Reading:**

**Supplementary Reading:**

**CE 2704 SURVEYING FIELD WORK**
2 Credits [0-0-3]
Chain Triangulation of a given area; Plotting the chain triangulation; Traversing a given area with Prismatic Compass; Plotting the compass traverse and graphical adjustment; Filling up with details with plane-table by i) radial and ii) intersection method; Solving two-point problem and three-point problem; Study of Dumpy level and Auto level; Differential levelling; Permanent adjustment of Dumpy level; Reciprocal levelling; Determination of sensitiveness of the bubble tube; Profile levelling; Longitudinal sectioning and cross sectioning – Contouring; Interpolation of contours and preparation of contour map of a given area.

**CE 3003 REMOTE SENSING AND GEOGRAPHICAL INFORMATION SYSTEM**
3 Credits [3-0-0]

Introduction to GIS, GIS components, Data sources and products, Spatial reference system and geo-referencing, Projection system, Data acquisition- raster and vector data, Registration and relating different data, Spatial analysis, Data integration, Data modelling, Data models, Data structures, Raster and Vector data models, Measurement of length, perimeter and area,
management, Database models, Data encoding, Geospatial analysis, Spatial statistics, Database query, Reclassification, Buffering and neighbourhood functions, Overlaying of Maps, Spatial interpolation, Surface analysis, and Network analysis.

Essential Reading:

Supplementary Reading:

CE 3004  DISASTER MANAGEMENT  3 Credits [3-0-0]
Introduction hazard, vulnerability and risk assessment, Risk and uncertainty analysis of disasters, Different type of natural and manmade disasters, National policies for Disaster management, Study of different techniques for early warning, preparedness, mitigation and prevention of any Disaster, Mechanisms for response, recovery and development of post-disaster activities, Adaptation strategies for disaster mitigation
Snow Avalanche disaster, Free-Thaw mechanism and disaster management; Biological disaster by bacteria, virus and toxins and its management mechanism; Disaster due to Climate change; greenhouse gases, depletion of ozone layer, aerosol and adaptation strategies to mitigate disaster, Climate Variability Index; Coastal erosion and its prevention using structural and non-structural measures; Cyclones, its impact, Coriolis force, Rosby number, design of safe structures to prevent disaster due to cyclones; Cold waves and disaster due to cold waves; Drought, meteorological, hydrological, agricultural and socio-economic droughts, drought severity and indexing, different methods to monitor, prevent droughts, early warning system for drought management; Earthquake, Rector scale and its impact, Crust, Mantle and Core of earth, tectonic plates and earth quake vibrations, disaster management by early warning mechanism and satellite technology; Fir disaster and its protection, impact of fire, tyeps of fire; Flood, disaster due to floods, Indian scenario, flood management using non-structural measures, Flood control structures; Heat waves, Sunstroke and disaster management; Land slide, types of landslides and its impact, prevention of landslides and management; Tsumani and its impact in coastal areas, preventive measures and preparedness for Tsunami disaster.

Essential Reading:
1. R. Jha, *Disaster Management*, Draft book to be published

Supplementary Reading:

CE 3107  FOUNDATION ENGINEERING  3 Credits[3-0-0]
Module I: Stresses in Soils: Boussinesq’s Equation: Vertical Stress distribution on horizontal and vertical planes, Newmark’s influence chart, Contact pressure distribution.
Module IV: Pile Foundation- Load carrying capacity of a pile (Static and dynamic formulae), Pile group, Settlement analysis of pile;
Module V: Earth Pressure, Retaining Structures and Sheet Pile Walls: Earth pressure Theories- Rankine Earth pressure theory, Coulomb’s Earth pressure theory.; Sheet pile walls: Pressure against sheet pile walls, cantilever and anchored bulk heads (free earth support method). Pressure against wallings in large trenches;

Essential Reading:

Supplementary Reading:

CE 3201       ADVANCED STRUCTURAL ANALYSIS       3 Credits [3-0-0]
Analysis of beams and frames by Kani’s method including sway conditions and double storied frames; Analysis of fixed arches by energy approach and Elastic centre method. Energy Theorems, theorem of conservation of energy, minimum potential energy theorem, Raleigh-Ritz method of analysis of beams, stable, neutral and unstable equilibriums; Study of Influence line diagram of indeterminate structures by Muller Breslue Principle; Basics of matrix method of Analysis, flexibility and stiffness method of analysis of beams and frames; Approximate lateral load analysis of frames.

Essential Reading:

Supplementary Reading:

CE 3202       DESIGN OF STEEL STRUCTURES       3 Credits [3-0-0]
Materials, Structures and Specifications, Riveted, Bolted & welded Connections, Design of Tension and Compression Members, Design of Beams, plate girders and gantry girders, Design of industrial buildings; Design of slab and gusseted base.

Essential Reading:

Supplementary Reading:
CE 3203  REINFORCED CONCRETE DESIGN  3 Credits [3-0-0]
Introduction; Basic Material Properties; Basic Design Concepts - Working Stress Method (WSM), Ultimate Load Method (ULM), Limit States Method (LSM); Behaviour in Flexure; Design of Beams and One-way Slabs for Flexure; Design for Shear; Design for Torsion; Design for Bond; Serviceability Limit States: Deflection and Cracking; Design of Two-way Slab Systems; Design of Staircases; Design of Compression Members; Design of Footings and Retaining Walls; Detailing and Construction Practices.

Essential Reading:
3. N. Subramanian, Design of Reinforced Concrete Structures (1st edition), Oxford

Supplementary Reading:
4. SP-16: Design Aids to IS 456-1978.

CE 3204  FINITE ELEMENT METHOD  3 Credits [3-0-0]

Essential Reading:

Supplementary Reading:


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**CE 3401 WATER RESOURCES ENGINEERING**

3 Credits [3-0-0]

Hydrologic cycle, catchment area and watershed, Rainfall and its characteristics, Rain gauges, Non-Recording and Recording type, average rainfall over a catchments, Evapo-transpiration, Pan evaporation, pan coefficient Infiltration, W-Index and \( \phi \) - Index; Hydrographs: Discharge formulae, characteristics of a Run off hydrograph, Unit hydrograph, S-hydrograph, Instantaneous hydrograph, synthetic Unit hydrograph, Duration Curve, Mass Flow hydrograph, Stream gauging, Flow rating curve, use of current meters for velocity measurement, Dye-dilution method of discharge measurement; Flood Control: Flood flows, Frequency studies, Statistical analysis for flood prediction, Method of flood control, Flood routing, Reservoir routing and Channel routing, River training works; Dock and Harbours: Natural and artificial Harbours, Selection of site, study of winds, tides and wave actions, Accretion and denudation, Principle of construction of Breakwaters, Quays and jetties, Wet and Floating Docks.

**Essential Reading:**


**Supplementary Reading:**


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**CE 3402 ADVANCED FLUID MECHANICS**

3 Credits [3-0-0]

Dynamic of Fluid Flow, One-Dimensional method, The Nervier Stokes Equation, Limiting Case, Applications; Boundary Layer Theory for low and high Viscosity, Boundary Layer thickness, Prandtl's Equation, Momentum Integral Equation, Pressure Distribution in boundary layer. Dimension analysis and similarities, Buckingham theorem, types of similarities, forces influencing hydraulic phenomenon, significance of dimensionless numbers, distorted model, and model proto type similarity law; Laminar and Turbulent Flow in Pipes, Reynolds experiment, mechanism of turbulent flow, Prandtls mixing length theory, Karmans similarity hypothesis, Universal velocity distribution near solid boundary, Hydro dynamically smooth and rough pipes. Power law for velocity distribution, Nikuradse experiment, Ageing of Pipes; Compressible Fluid Flow, Equation of motion, continuity equation and energy equation; Stagnation point and its properties, flow through ducts of varying areas, flow through convergent and divergent nozzles, effects of compressibility, shock waves, supersonic expansion and contraction; Ideal Fluid Flow, Circulation and Vorticity, Source and sink, combining flow field by super position, combined flow field for Engineering importance. Doublet in rectilinear flow and Doublet with Circulation; Flow past a cylinder curved flow and with circulation and their different combinations; Unsteady flow in bounded systems, Quasi-steady flow, unsteady flow in pipes and open channel flow. Finite difference representation of depth
dependent-discharge, Simulation of unsteady flow in pipes, channels and ducts. Development of St. Venant equation of continuity and motion Non uniform flow in open channel flow, equation of gradually varied flow. Classification of water surface profiles, location of hydraulic jump.

**Essential Reading:**


**Supplementary Reading:**


**CE 3505 ENVIRONMENTAL ENGINEERING**

3 Credits [3-0-0]

General requirement for water supply, Quality and quantity of water, Domestic water quality standards; Sources of water and their yield, population forecast, Design period; Intakes, pumping and transportation of water; Physical, chemical and biological characteristics of water and their significance, water quality criteria, water borne diseases, Appurtenances of water treatment and distribution systems. DO and BOD demand in streams.; Essentials of wastewater engineering, Quantities of wastewater and storm water, wastewater characteristics; Water and wastewater plumbing systems, Waste water collection and conveyance systems, Design of sewerage systems, Pumping of waste water.; Air pollution and pollutants, air quality, ambient and atmospheric standards, Sampling and monitoring of air pollutants. Prediction of air pollution dispersion, air quality modelling.; Solid and hazardous waste management-Generation, on-site storage, collection, separation, processing and disposal On-site storage methods, Collection systems-Vehicles, routing, route balancing and transfer stations, Processing methods, recovery and reuse of materials and energy, Disposal methods such as sanitary landfill, biological digestion & etc.

Introduction to solid and hazardous waste management, Collection techniques, equipment, costs and disposal, Engineering systems to minimize costs

**Essential Readings:**


**Suggested Readings:**


CE 3701 HIGHWAY ENGINEERING LABORATORY 2 Credits [0-0-3]
Determination of aggregate crushing value; Determination of Los Angeles abrasion value of aggregates; Determination of aggregate impact value; Determination of penetration value of bitumen; Determination of softening point value of bitumen; Determination of ductility value of bitumen; Determination of flash and fire point of bitumen; Determination of specific gravity of bitumen; Determination of fineness modulus of coarse aggregate; Determination of fineness modulus of fine aggregate; Determination of stripping value of aggregate; Determination of bulking of sand; Determination of workability of concrete by flow table; Determination of flakiness index and elongation index of coarse aggregate; Determination of specific gravity and water absorption of coarse aggregate; Aging of bituminous binders; Marshall method of mix design; Demonstration of advanced equipments for characterization of pavement materials.

Essential Reading:
1. Highway Engineering Laboratory Manual
2. Relevant I.S. Codes

CE 3702 RC STRUCTURES DESIGN PRACTICE 1 Credit [0-0-2]
Design and detailing of continuous beams and lintels; Design and detailing of one-way and two-way slabs; Design and detailing of staircases; Design and detailing of axially loaded and eccentric columns; Design and detailing of axially loaded and eccentric column footings.

CE 3703 FLUID MECHANICS AND HYDRAULIC MACHINES LABORATORY 2 Credits [0-0-3]
Verifications of momentum equation; Verifications of stokes apparatus; Calibration of Venturimeter; Verifications of Bernoulli’s equation through a convergent and divergent passage; Study of Major losses in Pipes; Study of Minor losses in Pipes; Velocity distribution in a pipe flow; Velocity distribution in open channel flow; Flow through Pipes; Reynolds’s experiment; Calibration of Notch; Experimental calculation of Metacentric Height; To study the performance characteristics of a Pelton turbine; To study the performance characteristics of a Francis turbine; To study the performance characteristics of a Kaplan turbine; To study the characteristics of a single stage Centrifugal pump; To study the Overall efficiency and percentage slip of a Reciprocating Pump; To determine the Critical Cavitation Number of a test rig.

CE 3704 STRUCTURAL ENGINEERING LABORATORY 2 Credits [0-0-3]
Basic tests for cement and concrete; Mix design of concrete of different grades; Tensile strength of different types of steel rebars; Tensile and Flexural strength of concrete of different grades; Testing of simply supported RCC beams for flexural failure; Testing of simply supported RCC beams for shear failure; Testing of RCC column; Non-destructive test of concrete; Permeability of concrete; Vibration analysis of plates.

Essential Reading:
1. Structural Engineering laboratory manual
2. Relevant BIS Codes of practice for mix design, rebar testing, concrete design etc.

CE 3705 GEOTECHNICAL ENGINEERING LABORATORY 2 Credits [0-0-3]
Visual Identification of soil; Grain Size Analysis (Mechanical Sieve Analysis, Wet Analysis); Atterberg’s limit (Liquid limit, Plastic Limit, Shrinkage Limit); Free Swell Test; Determination of Field Density by Core Cutter Method and by Sand Replacement Method; Specific Gravity of Soils (Fine and Coarse Grained); Determination of OMC & MDD by Using Light Compaction
Test, Relative Density of Coarse Grained Soils; California Bearing Ratio Test; Direct Shear Test, Vane Shear Test; Unconfined Compression Shear Test; Permeability test (constant head and Falling head test); Triaxial shear Test; Consolidation Test.

**Essential Reading:**

**Supplementary Reading:**
1. Indian Standard Code IS:2720

**CE 3706 ENVIRONMENTAL ENGINEERING LABORATORY 2 Credits [0-0-3]**

*Water Quality Analysis:* Determination of pH (Electrometric and Colorimetric); Determination of turbidity by using Nephelometer; Determination of alkalinity and acidity; optimum dose of coagulants by jar test; Total Hardness; Total solids and suspended solids; Residual chlorine; Chlorides; Chemical Oxygen Demand; Biochemical Oxygen Demand; Dissolved Oxygen; *Ambient Air Quality Analysis:* Respirable Particulate Matter (PM<sub>10</sub>); Total Suspended Particulate matter (TSP); Determination of SO<sub>2</sub> in ambient air; Determination of NO<sub>x</sub> in ambient air. *Noise Pollution measurement:* Indoor and ambient noise level analysis; *Microbiological Analysis of Water:* Microbiological culture analysis of bacterial samples; MPN Test.

**Laboratory Manual:**


**CE 4001 ESTIMATION, COSTING AND CONSTRUCTION MANAGEMENT 3 Credits [3-0-0]**

Methods of Estimation: Estimation of quantities for building, sanitary and water supply works, irrigation works, road works; Specifications: General specification, details specification for different building items; structural works, road works; Analysis of Rate: Analysis of rates for earth work, cement concrete, RCC, brick work, plastering, etc.; Contracts: Different methods of carrying out work contract system, contract document, types of contract, measurement book. Method of tendering; Construction management: Project, project development process, project evaluation, finance, material and man power development, project management, construction scheduling, Bar charts, activity times, network analysis, elements of PERT and CPM.

**Essential Reading:**

2. B. Sengupta and H. Guha, *Construction Management and Planning*, TMG.

**Supplementary Reading:**


**CE 4101 GROUND IMPROVEMENT TECHNIQUES 3 Credits [3-0-0]**

Introduction: Engineering properties of soft, weak and compressible deposits, natural on land, off-shore and Man-made deposits. Role of ground improvement in foundation engineering, methods of ground improvement, selection of suitable ground improvement techniques.
In-situ methods: In-situ densification soils, Dynamic compaction and consolidation, Vibrofloation, Sand pile compaction, Preloading with sand drains and fabric drains, Granular columns, Micro piles, Soil nailing, Ground Anchors, Lime piles, Injections, Thermal, Electrical and Chemical methods, Electro osmosis, Soil freezing


Essential Reading:

Supplementary Reading:

CE 4103 ADVANCED FOUNDATION ENGINEERING 3 Credits [3-0-0]
Shallow Foundation: Location and depth of foundation, Determination of bearing capacity of shallow foundation on cohesive and cohesion less soils, contact pressure and related study for rigid and flexible foundation. Floating or compensating foundations.

Deep Foundations:
(a) Piles: Load carrying capacity of single and pile group in cohesive and cohesion less soils (both end bearing end friction piles). Settlement of pile foundation. Negative friction and its effect on pile capacity.

(b) Well foundations: Types and components of well. Determination of depth, Size and number of wells under a heavy footing or pier, Phenomena of bottom heaving. Well sinking and related problems of sinking of well foundations.

Foundation on Expansive Soils; Identification / Characteristics of expensive soils, Swelling pressure and its effect on foundations for single end multi-storeyed buildings. Under-reamed piles, Accepted precautionary measures

Machine Foundations: Types of machines, Free and forced vibrations, vibration isolations, Design consideration for simple machine foundations under reciprocating, centrifugal and impact type machines.; Recent developments in foundation engineering.

Essential Reading:
1. S. Saran, *Analysis and Design of Substructures*, Oxford and IBH publication, New Delhi,

Supplementary Reading:

CE 4106 SOIL STRUCTURE INTERACTION 3 Credits [3-0-0]
Module I: Soil-Foundation Interaction: Introduction to soil-foundation interaction problems, Soil behaviour, Foundation behaviour, Interface behaviour, Scope of soil foundation interaction


Module IV: Theoretical solutions for settlement and load distributions, Analysis of pile group, Interaction analysis, Load distribution in groups with rigid cap.

Module V: Laterally Loaded Pile: Load deflection prediction for laterally loaded piles, Sub grade reaction and elastic analysis, Interaction analysis, Pile-raft system, Solutions through influence charts.

Essential Readings:

Supplementary Readings:

CE 4203 ADVANCED DESIGN OF REINFORCED CONCRETE STRUCTURES 3 Credits [3-0-0]

Design of combined footings, raft footing; Design of cantilever and counterfort type retaining walls; Design of water tanks-Underground, elevated and Intze type; Design of portal frames and domes.

Essential Reading:
3. Relevant IS codes.

Supplementary Reading:

CE 4205 ADVANCED MECHANICS OF SOLIDS 3 Credits [3-0-0]

Elementary Concept of Elasticity: Stresses in three dimensional bodies, equations of equilibrium, strain displacement relations, stress strain relations, compatibility equations, boundary conditions, plane stress, governing differential equation, Airy stress function(Cartesian co-ordinates). Theories of Failure: Theories of Failure and its graphical representation for two-dimensional cases. Thick walled cylinders: Thick cylinders subjected to internal and external fluid pressures, compound cylinders, shrink-fit. Energy Methods: Strain energy expression in three dimensions, strain energy due to axial load, bending and torsion, Castigliano’s theorems, Principle of virtual work, Unit load and unit couple method. Unsymmetrical bending: Properties of beam cross-sections slope of neutral axis, stresses and

**Essential Reading:**

**Supplementary Reading:**

**CE 4206 DESIGN OF INDUSTRIAL STEEL STRUCTURES**

**3 Credits [3-0-0]**

**Superstructures:** Analysis and Design of Towers, Chimneys, Pipe Racks, Silos and Bunkers, Shell Roof, Blast Wall, Liquid Storage Tank, Skid Frames. **Connections:** Weld Connection: Beam-to-column connection, Beam-to-beam connection, Column-to-foundation connection, Tube-to-tube connection, Tube-to-flanged connection, Other Connections; Bolted Connection

**Essential Reading:**

**Supplementary Reading:**

**CE 4301 ADVANCED TRANSPORTATION ENGINEERING**

**3 Credits [3-0-0]**

Railway: Introduction: History, Cross section and components of railway track, Problems of multi gauge system, wheel and axle arrangements, Coning of wheels, Train resistances, hauling capacity and tractive effort, Stresses in rail, sleepers, ballast and formation.; Components of Permanent way : Rails - Types of rail section, wear and failure in rails, Creep, Rail joints, Rail fittings, check and guard rails, Sleepers – types and specifications, Ballast - specifications, Formation, drainage of track ; Geometric design: Alignment, horizontal curves, super elevation, equilibrium cant and cant deficiency, Length of transition curves, Gradients and grade compensation, vertical curves; Points and crossing: Design and layout of turn-out, various types of track junctions and their configurations ; Signalling and Interlocking: Control of train movements, Signals, Principles of interlocking ; Airport; Air Transport Development, Aircraft characteristics, Airport planning and site selection, Obstruction and zoning laws - imaginary surfaces, approach zones and turning zones, Visual Flight Rules and Instrumental
landing systems; Geometric Design of Runways and Taxiways: Runway-orientation and configuration, Basic runway length and corrections, Geometric design elements, Taxiway design, Main and exit Taxiway, Separation clearance, Holding aprons, Typical airport layouts, Terminal building, gate position; Airport marking and lighting. ; Tunnel; Necessity, Tunnelling vs open cut, Size and shape, Transfer of surface alignment tunnelling in hard rock, soft soil and under water bodies- Use of shafts, shuttering and linings drainage and ventilation.

Essential Reading:

Supplementary Reading:

CE 4302 TRAFFIC ENGINEERING AND TRANSPORTATION PLANNING 3 Credits [3-0-0]
Traffic Engineering: Importance of Traffic engineering; Road User Characteristics, Human factors governing road user behaviour, vehicle characteristics, slow moving traffic characteristics in Indian conditions; Traffic Engg. Studies: Traffic Volume, Origin and Destination, Speed and delay; Measurements; Speed- density-volume relationships; Shock waves in Traffic flow, Headway Distribution; Highway capacity analysis- cases of different types of highways; Intersection; Parking types; Off street parking; Facilities; Traffic control devices: channelization, rotary and Traffic signals, Traffic Signs and making; Transportation Planning: Brief ideas about urban and regional transportation systems; Components of Transportation system planning; Land use planning, Trip generation and distribution, Traffic assignment and modal split, Optimal scheduling; Economic evaluation of transportation plans.

Essential Reading:

Supplementary Reading:
4. Relevant I.R. C. Codes.

CE 4303 PAVEMENT DESIGN 3 Credits [3-0-0]
Introduction: Classification of pavements, Difference between highway and runway pavements, Factors affecting structural design of Pavements, Characteristics of traffic loading, Concept of
VDF and Computation of design traffic; Principles of pavement design: Concepts of structural and functional failures, Performance criteria; Analysis of pavements: ESWL, Analysis of flexible and concrete pavements; Design of pavements: IRC, AASHTO and other important methods of design of bituminous and concrete pavements; Functional Evaluation of Pavements; Techniques for structural evaluation of pavements: Benkelman beam, Falling weight deflectometer and other equipments, Concepts of pavement maintenance management

**Essential Reading:**

**Supplementary Reading:**
5. Relevant I. R. C. and AASHTO Codes

**CE 4304 PAVEMENT MATERIALS 3 Credits [3-0-0]**
Conventional aggregates: Source, preparation, grading, testing and their evaluation, Bituminous binders- Properties, testing and applications ; Bituminous mixes- Design, testing and evaluation; Modelling of bituminous binders and mixes ; Materials for cement concrete and semi-rigid pavements, Design of mixes for stabilized roads ; Non-conventional and new pavement materials- their application and limitations ; Modern methods of testing and evaluation of paving materials

**Essential Reading:**
1. P. Chakroborty and A. Das, Principles of Transportation Engg., PHI Publication, 1st Ed. 2nd reprint 2005

**Supplementary Reading:**
2. Relevant IRC, ASTM and AASHTO and Other Codes, Specifications and Manuals.

**CE 4305 PLANNING AND DESIGN OF AIRPORTS 3 Credits [3-0-0]**
Air Transport Development, Aircraft characteristics, Airport planning and site selection, Obstruction and zoning laws - imaginary surfaces, approach zones and turning zones, Visual Flight Rules and Instrumental landing systems ; Geometric Design of Runways and Taxiways: Runway- orientation and configuration, Basic runway length and corrections, Geometric design elements, Taxiway design, Main and exit Taxiway, Separation clearance, Holding aprons, Typical airport layouts, Terminal building, gate position; Airport marking and lighting
Design of Airport Pavements, ACN-PCN system, Maintenance and rehabilitation of airport pavements, Airport Drainage

**Essential Reading:**

**Supplementary Reading:**
2. Relevant Codes and Specifications.

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**CE 4306 RAILWAY AND TUNNEL ENGINEERING**

3 Credits [3-0-0]

Railway; Introduction: History, Cross section and components of railway track, Problems of multi gauge system, wheel and axle arrangements, Coning of wheels, Train resistances, hauling capacity and tractive effort, Stresses in rail, sleepers, ballast and formation.; Components of Permanent way: Rails - Types of rail section, wear and failure in rails, Creep, Rail joints, Rail fittings, check and guard rails, Sleepers – types and specifications, Ballast - specifications, Formation, drainage of track; Geometric design: Alignment, horizontal curves, super elevation, equilibrium cant and cant deficiency, Length of transition curves, Gradients and grade compensation, vertical curves; Points and crossing: Design and layout of turn-out, various types of track junctions and their configurations; Signalling and Interlocking: Control of train movements, Signals, Principles of interlocking

Tunnel; Necessity, Tunnelling vs open cut, Size and shape, Transfer of surface alignment, Tunnelling in hard rock, soft soil and under water bodies, Use of shafts, shuttering and linings, Drainage and ventilation in Tunnels

**Essential Reading:**
1. S. Chandra & M. M. Agarwal, Railway Engineering, Oxford University Press, New Delhi, 1st Ed. 2007.

**Supplementary Reading:**

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**CE 4400 HYDRAULICS ENGINEERING**

3 Credits [3-0-0]

Basic properties of water; Determination of hydrostatic forces; Kinematics of flow; Potential flow; Continuity, Energy and Momentum principles; Open Channel Flow: Channel Characteristics and parameters, Uniform, flow, Critical flow, Specific Energy concepts, Gradually Varied Flows, Rapidly Varied flow with special reference to hydraulic jump., Boundary Layer Theory, Boundary layer characteristics, Integral, Momentum equation, onset of turbulence, properties of turbulent flow, skin friction, drag, lift and circulation. Pipe Flow: Laminar and Turbulent, flow in Smooth and Rough pipes, pipe network analysis, Losses in, pipes. Dimensional analysis; Hydraulic similitude and Modelling

**Essential Reading:**
CE 4401 IRRIGATION ENGINEERING 3 Credits [3-0-0]
Introduction: Necessity of Irrigation in India, Advantages and disadvantages of Irrigation, Techniques of water distribution in farms. Quality of irrigation water, Crops and crop season, Consumptive use, Irrigation requirements. Estimation of consumptive use of water by climatic approaches, Irrigation efficiencies, Soil moisture-irrigation relationship; Canal Irrigation: Classification of canals, Canal losses, Alignment of canals. Design of Irrigation Canals: Design of stable channels using Kennedy's and Lacey's theory, Garret's diagram, Cross section of irrigation canals, Lining of Irrigation Canals: Advantages and economics of lining, Various types of lining, Design of lined canals, Types of Cross-Drainage Works: Types of CD works, Selection of a suitable type to suite a particular condition, Design consideration for CD works, Canal Falls: Necessity, Proper location, Types, Design and detailing of one type of fall; Weirs and Barrages: Weirs and Barrages, Types of weirs and barrages, Layout of a diversion head work, Introduction of different components of a diversion head works, Design of weirs and barrages: Bligh's creep theory, Design of weir using Bligh's theory, Lane's weighted creep theory, Khosla's theory, Khosla's method of independent variables, Exit gradient; Dams: Typical cross section, Various forces acting on gravity dam, Combination of forces for design, modes of failure and criteria for structural stability, High and low gravity dam, Design of high dam, Typical section of low gravity dam, Earth and Rock fill Dams: Types, Causes of failure, Preliminary section of an earth dam, Preliminary section of an earth dam, Seepage control in earth dams, Spillways: Descriptive study of various types of spillways; Reclamation of Water Logged and Saline Soils: Causes and control of water logging. Reclamation of saline and alkaline land, Surface and Sub-surface drainage, River training works.

Essential Reading:

Supplementary Reading:

CE 4403 COMPUTATIONAL FLUID DYNAMICS 3 Credits [3-0-0]
Introduction to Computational Fluid Dynamics, Application to different Branch of Science and Engineering, Governing equations for fluid flow: Continuity equation, momentum equation and energy equation, Finite difference approach, Classification of partial differential equations, Parabolic, Hyperbolic and elliptic equations, Discretisations of the 1-Dimensional, 2-Dimensional partial differential equations and its solutions. Finite difference formulations, Explicit finite difference schemes, Implicit finite difference schemes, Initial and Boundary conditions, significance of model boundary conditions, Grid generation techniques, Von Neumann Stability analysis. Solution of Governing equations and Application to different fluid flow problems.

Essential Reading:

Supplementary Reading:

CE 4404 ENGINEERING HYDROLOGY 3 Credits [3-0-0]
Understanding hydrologic cycle, water availability, Water balance
Precipitation mechanisms, Measurement of precipitation, Infiltration, Evaporation and transpiration,
Surface runoff, Hyetographs, Hydrographs, Derivation of UH, S-curve Change of unit period of UH, Derivation of an average UH
Developing synthetic unit hydrograph, Development of rainfall runoff relationship, Flow duration curves, Flood routing,
Darcy’s law, Gradient of hydraulic head, Aquifer properties, Equation of groundwater flow

Essential Reading:

Supplementary Reading:

CE 4405 OPEN CHANNEL FLOW 3 Credits [3-0-0]
Open- channel flow and its classifications, measurement of velocity, velocity distribution,
pressure distribution, specific energy, Specific force and critical state of flow, section factor for critical flow; Uniform flow, determination of roughness coefficients and the factors affecting the roughness, computation of uniform flow, flood discharge, determination of normal depth and velocity, flow in composite roughness; Design of channels for uniform flow in non-erodable and erodable with grassed channels; Dynamics of Gradually varied flow and classification of flow profile, methods of computation, Dynamics of spatially varied flow - analysis of flow profile and computation by method of numerical integration; Rapidly varied flow, classification, flow over spillway, Hydraulic Jump, types with characteristics of jump, the surface profile and location of the jump, jumps as energy decapitator, Rapidly varied flow through non-prismatic channels; Unsteady flow, dynamics of gradually varied unsteady flow, solution of unsteady flow equations, rapidly varied unsteady flow, positive and negative surges, flood routing, principle and methods of flood routing.

Essential Reading:

Supplementary Reading:

5. H. Rouse, Engineering Hydraulics, John Wiley and Sons.

CE 4406 WATER RESOURCES PLANNING AND MANAGEMENT 3 Credits [3-0-0]
Hydrologic Cycle: Rainfall, Rain gauge, Evaporation, Transmission, Infiltration, Rainfall excess, Base flow, Average rainfall, Runoff, DRH; River basins: Catchment area, River stages in hilly-plain and deltaic area. Storage structures: Dams, Weirs, Barrages their location. Classification of dams and Multipurpose dams; Requirement of water for various needs: Domestic, Irrigation, Power generation etc. Reservoir planning. Rain water harvesting for Domestic Industrial and Irrigation Uses; Ground water: Types of aquifers, their properties, ground water table, Ground water yield, well hydraulics.

Essential Reading:

Supplementary Reading:
1. V. P Singh, Elementary Hydrology, Prentice Hall of India.

CE 4502 ADVANCED ENVIRONMENTAL ENGINEERING 3 Credits [3-0-0]
Engineered systems for water treatment: aeration, coagulation, flocculation, sedimentation, softening, filtration, adsorption, ion exchange, and disinfection. Water distribution systems. Primary and secondary treatment of wastewater; Wastewater disposal standards, Biological wastewater treatment systems: Aerobic processes - activated sludge process and its modifications, trickling filter, RBC, Anaerobic Processes - conventional anaerobic digester, High rate and hybrid anaerobic reactors. Tertiary treatment of industrial wastewater including removal of nitrate, sulphate, phosphorous, pathogens, colour, odour, TDS, COD and residual BOD; Sector specific issues in management of industrial wastewater including petrochemical, textile, food processing, pharmaceutical, fertilizer, pesticides etc.; Sludge digestion and handling. Disposal of effluents and sludge; Policy and legislation including challenges posed by various sectors of industries and legislation framework and regulations in India; Case studies.

Essential Reading:

Supplementary Reading:

**CE 4503 ENVIRONMENTAL IMPACT ASSESSMENT**  
3 Credits [3-0-0]

Evolution of EIA; EIA at project; Regional and policy levels; Strategic EIA; EIA process; Screening and scoping criteria; Rapid and comprehensive EIA; Specialized areas like environmental health impact assessment; Environmental risk analysis; Economic valuation methods; Cost-benefit analysis; Expert system and GIS applications; Uncertainties; Practical applications of EIA; EIA methodologies; Baseline data collection; Prediction and assessment of impacts on physical, biological and socio-economic environment; Environmental management plan; Post project monitoring, EIA report and EIS; Review process. Case studies on project, regional and sectoral EIA; Legislative and environmental clearance procedures in India and other countries, Siting criteria; CRZ; Public participation; Resettlement and rehabilitation

**Essential Reading:**


**Supplementary Reading:**


**CE 4504 AIR QUALITY MANAGEMENT**  
3 Credits [3-0-0]

Air pollutants, Sources, classification, Combustion Processes and pollutant emission, Effects on Health, vegetation, materials and atmosphere, Reactions of pollutants in the atmosphere and their effects - Smoke, smog and ozone layer disturbance etc; Atmospheric diffusion of pollutants and their analysis, Transport, transformation and deposition of air contaminants on a global scale, Air sampling and pollution measurement methods, principles and instruments; Emission factors, regulations, control strategies and policies. Particulate Pollutant Control: Settling chambers - laminar and turbulent flow; Filtration - interception; Impaction; Convective diffusion; Collection of particles by cylindrical fibres and granular beds; Electrostatic precipitation - field and diffusion charging; Electrical migration velocity; Cyclones - laminar and turbulent flow; Wet collectors; Efficiency and dimensions of particle control devices. Gaseous Pollutant Control: Gas absorption in tray and packed towers; Stage efficiency; Liquid/gas rates; Equilibrium number of stages/packed height; Absorption with/without chemical reaction; Removal of SO2; Adsorption in fixed beds; Breakthrough; Removal of HCs/VOCs; NOx removal from effluent streams; Wet scrubbers. Integrated air pollution control systems; Effect of process parameters on performance of control systems.

**Essential Reading:**


Supplementary Reading:

CE 4505 ENVIRONMENTAL MANAGEMENT IN INDUSTRY 3 Credits [3-0-0]
Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Unit operations in separation technology; Separation technologies as tools for waste minimization. Process optimization for cleaner industrial processes; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; Environmental regulations and policies; Environmental protection laws and acts; Environmental management systems; Strategies for management of resources, Corporate and international charters and protocols; Risk assessment; Environmental impact assessment; Industrial ecology, Pollution prevention; Waste minimisation and sustainable development; Life cycle assessment; Environmental audits; Eco-labelling of products; Performance indicators; Environmental economics. Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp and paper, textile, electroplating, leather, dairy, cement and other industries.

Essential Reading:

Supplementary Reading:

CE 4701 GEOTECHNICAL ENGINEERING DESIGN PRACTICE 1 Credit [0-0-2]
1. Interpretation and use of In-situ tests (SPT, CPT, PLT, PMT, DMT) for design of foundations
2. Geotechnical Design of shallow footing for compression, bending and uplift
3. Design of piles under compression, lateral and uplift forces
4. Design of well foundation
5. Design of soil slopes
6. Concept of Computer aided design and use of software packages for analysis and design of
   a. Soil slopes with and without reinforcement
   b. Sheet pile
   c. Pile foundation
   d. Liquefaction analysis

Essential Reading:
1. Online manuals of the software used for drawing and design.

**CE 4702**  
**WATER RESOURCES ENGINEERING DESIGN PRACTICE**  
1 Credit [0-0-2]

Design of unlined canal using Kennedy’s theory; Design of unlined canal using Lacey’s theory and comparing the design using Garret’s diagram; Economics of canal lining-finding the cost-benefit ratio by lining an unlined canal; Design of a trapezoidal concrete lined canal section; Calculation of balancing depth of cut for a canal section; Draw the phreatic line for a homogeneous earth dam without filter; Draw the phreatic line for an earthen dam with horizontal filter and that for a zoned section; Design of a strainer type tube-well; Design of an unflumed, non-metered straight glacis fall

**Essential Reading:**

**CE 4703**  
**STEEL STRUCTURES DESIGN PRACTICE**  
1 Credit [0-0-2]

Analysis and design of Roof trusses; Analysis and design of Plate Girder Bridge; Analysis and design of Elevated water tank

**CE 4704**  
**TRANSPORTATION ENGINEERING DESIGN PRACTICE**  
1 Credit [0-0-2]

Design and drawing of a HPC culvert to cater to a given stream flow; Design and drawing of a RCC slab culvert on a highway; Design and drawing of superstructure of a T-Beam Bridge; Design and drawing of a RCC Box culvert to cater to a given stream flow and terrain condition; Design of suitable foundation and pier/abutment of a bridge; Study of geometric design characteristics of highways; Practice on blending of aggregates; Calculation of earthwork for highways and railways; Setting out of horizontal and vertical curves; Design of flexible pavement

**Essential Reading:**

**Supplementary Reading:**

**CE 4705**  
**ENVIRONMENTAL ENGINEERING DESIGN PRACTICE**  
1 Credit [0-0-2]

Design of river intake and pump house; Design of water treatment plants: Mixing tank; Flocculator; Sedimentation tank; Rapid gravity filter; Wash water tank; Under drainage system. Design of effluent treatment plant: Screening tank; Grit chamber; Primary clarifier; Trickling filter; Aeration tank; Secondary clarifier; Design of septic tank and soakage pit; Design of Air pollution Control Systems; Particulate and Gaseous pollutant control.

**Essential Reading:**

**Supplementary Reading:**

**CE 4706** COMPUTER AIDED DESIGN PRACTICE 1 Credit [0-0-2]
Revisiting different methods of analysis of beams and frames, different philosophies of design of RCC structures; Concept of computer aided design, introduction of software packages used for analysis and design of structures including STAAD and SAP. ; Analysis and design of a double storied frame using STAAD, SAP and check by any of analytical methods including Kani’s method. ; Drawing of any utility building (two storied and above) like residential complex, software office, Hotel, hospital, Bank, post office at different places of the country using any graphical package including AutoCAD, analysis and design using software like STAAD Pro, SAP etc. ; Concept of earthquake resistant design of structures in the above design of utility buildings.

**Essential Reading:**
1. Online manuals of the software used for drawing and design.

**DEPARTMENT OF CHEMICAL ENGINEERING**

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Course objective:
To provide the students the fundamentals of fluid dynamics and practice in the analytical formulation of fluid dynamics problems using Newton’s Laws of motion and thermodynamics. Analyze and solve laminar and turbulent flows in channels, conduits, through porous media, moving bodies, multiphase flows, and performance of fluid transportation machineries.

Course Description:
Definition of Fluid, Properties and classification of fluids, fluid statics, buoyancy, pressure measurement, Fluid flow phenomena, Nature and classification of flow, Kinematics of fluid flow, velocity field; stream function; irrational flow, Dynamic properties of fluid, Flow measurement: Orifice meter, venture meter, Pitot tube, and Rota meters. Brief introduction to non-conventional methods: Laser Doppler velocimetry, Particle image velocimetry, ultrasonic flow meters, electromagnetic flow meters, Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Differential balances of fluid flow: derivation of continuity and momentum (Navier-Stokes) equations for a Newtonian fluid. Applications to plane Couette, plane Poiseuille and pipe flows, High-Reynolds number flows: in viscous flows and potential flows, Pipe flows and fittings: laminar and turbulent flows; friction factor charts, losses in fittings, flow in manifolds, Dimensional analysis and similitude: Buckingham Pi theorem and applications, Model analysis, Fluid transportation: Valves and Pumps and Compressors, Agitation and mixing: power consumption, mixing times, scale up, Mixing in pipe flow, turbulent and free jets, Flow past immersed bodies: flow past a sphere and other submerged objects, fluid friction in porous media, Flow through packed beds and fluidized beds, The Boundary layer, Boundary Layer Theory, Introduction to turbulent flows, Transition to turbulence, Fluctuations and time-averaging, Basic equations of turbulent flow, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow.

Essential Reading:

Supplementary Reading:
Graphical Equilibrium-Stage method and algebraic method for determining number of stages, stage efficiency, design of packed tower, height equivalent to a theoretical plate (HETP), Distillation: Vapor-Liquid Equilibrium (VLE), Flash, steam and batch distillation, McCabe-Thiele and Ponchon-Savarit graphical method for calculating equilibrium stages in trayed towers for binary system, Distillation in a packed tower, Tray efficiency, Multicomponent Distillation, Azeotropic and extractive distillation.

Essential Reading:

Suggested Reading:

CH 2114 Heat Transfer Operations 3 credits [3-0-0]
Course Objective: To enable the students to understand the basic heat transfer mechanisms, performance of evaporators and heat exchangers.

Course Description:

Essential Reading:

Suggested Reading:

CH 2124 Fundamentals of Heat and Mass Transfer 3 credits [3-0-0]
Course Objective: To enable the students and equip them with fundamentals of mass transfer and heat transfer

Course Description:
Mass Transfer: Fick’s law of diffusion, Steady state diffusion, Measurement and prediction of diffusion coefficients, Molecular diffusion in liquids, Knudsen diffusion, Convective Mass Transfer, Types of mass transfer coefficients, dimensionless groups in mass transfer and various correlations, The wetted wall column experiment, Film theory, Penetration theory,
Analogies in mass, heat and momentum transfer: Reynolds analogy, Chilton-Colburn analogy, Phase equilibrium, Raoult’s and Henry’s law, Overall mass transfer coefficients, Vapor-Liquid Equilibrium (VLE), Flash, steam and batch distillation, McCabe-Thiele graphical method for calculating equilibrium stages in trayed towers for binary system, Distillation in a packed tower, Tray efficiency.


Essential Reading:


Suggested Reading:


CH 2125

Introduction to Fluid Dynamics

3 credits [3-0-0]

Course Description:
Definition of Fluid; Properties and classification of fluids; Fluid statics, buoyancy, pressure measurement; Fluid flow phenomena: Nature and classification of flow, Kinematics of fluid flow, velocity field, stream function, irrational flow; Flow measurement: Orifice meter, venturi meter, Pitot tube, and Rota meters; Macroscopic Balances: derivation of integral balances for mass, energy and momentum; Differential balances of fluid flow: derivation of continuity and momentum equations for a Newtonian fluid; Laminar flow: inviscid flows and potential flows, Couette flow, Poiseuille flow, Flow through Pipes and fittings; Dimensional analysis and similitude: Buckingham Pi theorem and applications, Model analysis; Fluid transportation: Valves and Pumps and Compressors; Agitation and mixing: power consumption, mixing times, scale up; Flow past immersed bodies: flow past a sphere and submerged objects of different shapes ; Flow through packed beds and fluidized beds.

Essential Reading:


Suggested reading:


CH 2150

Fluid Dynamics Laboratory

1 credits [0-0-2]

Course Objectives: The basic aim is to perform practical studies on various types of fluid flow systems and determine or estimate various characteristic parameters associated them.

Course Description:

1. Friction losses in a Straight pipe.
2. Friction losses in a various type of bends and fittings in a piping network.
3. Reynold’s Experiment.
4. Verification of Bernoullis Theorm.
5. Verification of Darcy’s Law.
6. Flow through Packed Bed.
7. Separation in Centrifugal Separator.
10. Study of reciprocating pump characteristics.
11. Study of centrifugal pump characteristics.
12. Friction loss through a Helical coil.

CH 2156                 Unit Operations Laboratory - I                1 credits [0-0-2]

Course Description:
1. Dynamics of First Order Systems.
2. Characterization of ON-OFF temperature controller.
3. Friction losses in a Straight pipe.
4. Reynold’s Experiment.
5. To find out the thermal conductivity of liquids.
6. To find out the average heat transfer co-efficient in forced convection.
7. Determination of diffusivity of organic vapors in air.
8. Determination of vapor-liquid equilibrium (VLE) or T-x-y diagram for a binary system
9. Determination of composting of the supplied sample of Coal by Proximate Analysis
10. To find the effect of temperature on viscosity of the supplied liquid fuels using Redwood viscometer
11. Determination of average particle size of a mixture of particles by sieve analysis.
12. Study and operation of Jaw crusher and thereby verification of Ritinger’s constant.
13. Study and operation of a batch reactor.
14. Study and operation of a CSTR.

CH 2211                 Chemical Process Calculations                3 credits [2-1-0]

Course objective:
It aims at providing fundamental knowledge of chemical engineering and application of this knowledge in the solving of material and energy balances of chemical processes.

Course Description:

Essential Reading:

Suggested Reading:
Course objective: The aim of the course is to provide students an adequate knowledge of various process instruments and their characteristics.

Course Description:
Elements of instruments, Static characteristics, Dynamic characteristics, Applications of Laplace transforms in instruments, Responses of first & second order instruments and capacitance; Temperature measuring instruments like Bimetallic, Vapour pressure, Thermocouples, Automatic Potential Recorders, Resistance thermometers, Radiation pyrometers, Optical Pyrometers, Photo-electric Pyrometers, Thermistors, Responses of these instruments; Composition measuring instruments: Spectroscopic methods, Thermal conductivity cells, Carbon dioxide analyser, Humidity measurement, Moisture in paper and lumber, pH meter, Oxygen analyser, polarograph, Refractometer, Chromatography, Colorimetry, Combustible gas analysers; Measurement of pressure and vacuum: Manometers, Pressure spring, McLeod gauge, Pirani Gauge, Ionization Gauge, Thermocouple Gauge, Responses of these instruments; Measurement of flow properties: Viscosity and specific gravity measurement, Level measuring devices, Flow measuring devices, measurement of displacement; Biosensors and its applications; Process instrumentation diagram.

Essential Reading:

Suggested Reading:

CH 2410 Fuels and Combustion 3 credits [3-0-0]

Course Objectives: The basic course objective is to acquaint students with the fundamental properties of solid; liquid and gaseous fuels and their industrial applications and designing furnaces for combustion processes.

Course Description:
Solid fuels: Coal origin, Chemical composition, Calorific value, Classifications, Characteristics and Distribution of Indian coals, Coal storage, Coal washing and blending, Petrographic constituents of coal, Carbonization of coal, Manufacture and properties of metallurgical coke, Recovery of byproducts; Liquid fuels: Origin and composition of crude oil, distillation of crude oil and properties of gasoline, kerosene and diesel oil, Breaking and rebuilding processes like Cracking, Reforming, Polymerization, Coal tar distillation, Shale oil; Gaseous fuels: Natural gas, Coal gas, Coke oven and blast furnace gas, Manufacture of water gas and producer gas, Carbureted water gas; Synthetic fuels: Hydrogenation of coal, Fischer-Tropsch synthesis; Introduction to nuclear fuels and nuclear reactors; Combustion of solid fuels, Calorific values, Adiabatic flame temperatures, Combustion calculations, Gas analysis, Furnace design.

Essential Reading:

Suggested Reading:
Course Objective:
Thermodynamics deals with physical law of nature, its irreversibility, entropy, and energetic evolution of properties of matters. It deals with multi-component multi-phase behaviour of fluid, solution non-ideality, and chemical reaction equilibria. The objective of this course is to impart the fundamentals on thermodynamic phase behaviour, equilibria enhanced with three chemical reactions, thermodynamic efficiency of steady state devices and solution non-ideality, which are considered as necessary inputs to the courses like mass transfer, separation process, energy analysis and thermal design.

Course Description:

Essential Reading:

Suggested Reading:

Course Objective:
Course Description:
Introduction to Microbiology: Structure of cells, types of cells; Introduction to Biochemical process industries: Industrial alcohols, antibiotic, enzymes, vitamins, single cell process; Fermentation mechanisms and kinetics: Kinetic models of microbial growth and product formation; Fermentation types: Batch and continuous fermentation; Bioreactors: Types of bioreactor and design; Sterilization; Sterilization of media and air, equipment, batch and continuous sterilizer design; Biochemical product separation and recovery: Membrane separation process, chromatographic method; Application to waste water treatment: Activated sludge process, aerobic and anaerobic processes.

Essential Reading:

Suggested Reading:
Course Objectives: The basic aim is to perform practical studies on various types of solid and liquid fuels for estimating their properties and subsequent interpretations.

Course Description:
1. Determination of composting of the supplied sample of Coal by Proximate Analysis
2. To find the effect of temperature on viscosity of the supplied liquid fuels using Red wood viscometer
3. To find the effect of temperature on viscosity of the supplied samples of lubricating oil using Engler’s viscometer
4. To find the Flash and Fire points of the supplied samples of liquid fuel using (i) Pensky-Martens closed cup apparatus (b) Abel closed cup apparatus (c) Cleveland open cup apparatus
5. To find the Aniline point and Diesel Index of the supplied samples of liquid fuels
6. To find the Carbon Residue of the supplied sample of lubricating oil / oil mixture using Conradson apparatus
7. To find the moisture content of the supplied samples of liquid fuel / Crude oil using Dean and Stark apparatus
8. To find the Pour point and Solidification point of the supplied samples of liquid fuels
9. To find the Calorific value of liquid fuel using Bomb calorimeter (ash free basis)
10. To determine the Smoke Point of kerosene oil using Smoke Point Apparatus
11. To determine softening point of Bituminous materials using Ring and Ball apparatus
12. To determine the viscosity of petroleum products using Saybolt viscometer

CH 2451 Biochemical Engineering lab 2 credits [1-0-2]
1. Different sterilization and inoculation techniques.
2. Preparation of various types of media.
3. Effect of pH, Substrate conc. on cell growth.
4. Effect of temperature on cell growth.
5. Determination of volumetric mass transfer co efficient (Kla)
7. Determination of size and density of the microbial cells.
8. Determination of thermal death rate constant.
9. Preparation of immobilized whole cell system.
10. Substrate degradation, cell growth and product formation kinetics using free cells and whole cell immobilization.
11. Treatment of sample waste water in a bioreactor
12. Production of Acetic acid using fermenter.

CH 3111 Process Equipment Design 4 credits [3-1-0]
Course Objective: To help the students to design heat and mass transfer equipments. To help the students to design heat and mass transfer equipments along with the design knowledge of mechanical aspects of process equipments.

Course Description:
Detailed process design of the following equipment’s; Heat exchangers concentric tube, shell and tube types. Condensers—condenser coolers and superheater condensers for single vapour—only. Evaporators single and multi-effects, Absorbers for binary systems without reactions— Distillation columns for binary mixtures along with tray hydraulics, Rotary dryers; Multi- component Distillation Column Design. Design of storage tanks, pressure vessels and auxiliariesesign of storage tank and pressure vessel along with its accessories like nozzles, flanges, head and supports such as bracket, skirt and saddle support. Design of storage tanks, pressure vessels and auxiliaries. Design of storage tanks, pressure vessels and auxiliaries.

Essential Reading:

Suggested Reading:
Course objectives: This subject illustrates more recently developed unit operations like adsorption and membrane separation along with conventional unit operations like drying, leaching, solvent extraction, crystallization and industrial cooling operations. The area covered in this syllabus basically acquaints students with various types of contacting systems viz. liquid-liquid, solid-liquid, gas-solid with their technical insights.

Course Description:
Humidification and dehumidification: Basic terminologies, Wet bulb and adiabatic saturation temperatures, Psychrometric chart and its use, Cooling tower calculations and design, Drying: Drying equilibria, Drying rate curve, Classification of drying equipments and their design methodologies, Solid-Liquid extraction or Leaching: Solid-liquid contacting strategy and equilibrium, Supercritical fluid extraction, Liquid-Liquid extraction: Liquid-Liquid equilibria (LLE), Solvent selection, Design calculations of stage wise extraction, Triangular diagram, Adsorption: Characteristics and properties of adsorbents, Adsorption isotherms, Heat of adsorption, Breakthrough analysis, Pressure swing and temperature swing adsorption, Simulated moving bed systems, Crystallization: Nucleation and crystal growth, Crystal size distribution, Equipment for solution crystallization: batch crystallizers, cooling crystallizers, vacuum and evaporating crystallizers, Membrane separation: Materials, Types and preparation of membranes, membrane characterization, Transport in membranes, Microfiltration, Ultrafiltration, Nano filtration, Reverse Osmosis and Pervaporation.

Essential Reading:

Suggested Reading:
4.

Course Objective:
- Provide an introduction to individual / simultaneous momentum, energy and mass transport processes.
- Teach student how to develop mathematical representation of physical process and get its analytical solution using proper initial and boundary conditions for analysing the system performance.
- Help student to understand the analogy among the transport processes.

Course Description:
Momentum transport: Viscosity and mechanism, Temperature and pressure dependence of viscosity (gases at low density); Velocity distributions in laminar flow, Shell momentum balances, Equations of changes for isothermal system (compressible), Unsteady state viscous flow, Interphase transportations in isothermal system, Friction factor; Shell energy balances, Heat conduction through composite walls and in cooling fin forced and free convection; Equations of change for non-isothermal systems, Equations for energy in rectangular coordinates. Mass transport: Diffusivity and mechanism, Temperature and pressure dependence of mass diffusivity; Concentration distributions in solids and in laminar flow, Shell mass balances, diffusion through a stagnate gas film, Diffusion with homogeneous and heterogeneous chemical reactions, diffusion into a falling liquid film, Diffusion and chemical reaction inside a porous catalyst. Equations of continuity for a binary mixture in rectangular coordinates; Inter-phase transport in multi-component system, Definition of binary mass transfer coefficients in one phase, Correlations of binary mass transfer coefficients in one phase at low mass transfer coefficients and in two phase at low and high mass transfer rates.
Essential Readings:


Suggested Readings:


CH 3151 Heat Transfer Operation Laboratory 1 credits [0-0-2]

Course Description:

1. To find out the thermal conductivity of liquids.
2. To find out the average heat transfer co-efficient in forced convection.
3. Find out the Heat Transfer Coefficient during drop wise and film wise condensation.
4. To find out the emissivity of a surface.
5. To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall.
6. To find out the average heat transfer co-efficient in natural convection.
7. To find out the Stefan Boltzmanns constant and study the effect of hemisphere temperature on it.
8. To study the heat transfer in agitated vessel.
9. To find out the overall heat transfer co-efficient of a double pipe heat exchanger.
10. To find out the overall heat transfer co-efficient of 1-2 shell & tube heat exchanger.
11. To find out the overall heat transfer co-efficient of a Finned Tube heat exchanger
12. Study economy and the capacity of single effect evaporator and determine overall heat transfer co-efficient

CH 3152 Mass Transfer Operations Laboratory 2 credits [0-0-3]

Course Objectives: The basic aim is to conduct practical investigations on various mass transfer processes for a thorough understanding and a detailed insight to support the theoretical knowledge.

Course Description:

1. (a) Determination of diffusivity of organic vapors in air (b) Determination of diffusivity of a naphthalene ball in air
2. Determination of vapor-liquid equilibrium (VLE) or T-x-y diagram for a binary system
3. Determination of drying efficiency of a fluidized bed dryer
4. Determination of drying efficiency of a rotary dryer
5. Determination of absorption of CO$_2$ in a packed bed absorption tower
6. Binary separation of Methanol-Water system in a packed bed distillation column
7. Binary separation of Methanol-Water system in a bubble cap distillation column
8. Determination of extraction and recovery percentages of a heavy metal contaminated feed in liquid membrane application
9. Determination of steady state flux of ceramic composite membranes and estimation of its porosity
10. Determination of flux by studying permeation via a hollow fiber membrane and a polymeric membrane module.
**Course Objectives:** The basic aim of this course is to acquaint students with the fundamentals of reservoir and petroleum production for both crude oil and natural gas across various on and off-shore terrains across the globe and challenges involved therein.

**Course Description:**
Global trends and geo-political analysis, Statistical data on oil and natural gas, Properties of oil and natural gas, Reservoir characteristics; reservoir deliverability and forecast on well production, Drilling methods and drill mud analysis, Production decline and enhanced oil recovery techniques, Directional drilling and artificial lift methods: Matrix acidizing, Hydraulic fracturing, Production optimization and pipeline networking, Onshore and Off-shore drilling and production.

**Essential Reading:**

**Suggested Reading:**

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**Course Objective:**
It’s a relatively new area of science and engineering that has generated excitement worldwide due to its interdisciplinary nature and wide range of applications. The nanoscale materials are important because those have different properties at the nanoscale than the bulk or micro scale. So, the objective of this course is to focus on the nanoscale properties and to give an overview of the exciting advancement in this area.

**Course Description:**
Introduction to nanotechnology, definition, history. What makes the nanoscale so different from the other length scales by considering the under pinning science (i.e.nanoscience) and some key examples of nanotechnology; Properties in nanoscale: Extensive and Intensive properties, change in physical properties like color, melting point, electrical, magnetic, and mechanical. Quantum mechanical approach to explain the properties change in nanoscale. Theory of size dependent melting point, effect of grain size and grain boundary on mechanical properties of nanomaterial’s. Methods of synthesis of nanometers fabrication-“Top-down” vs. “bottom-up” approaches. A brief idea on synthesis of different nanomaterial’s. Theory of nucleation and growth. Brief introduction to application of nanoparticles in catalysis, biotechnology, sensor etc. Characterization of nanoparticles by Scanning probe microscopes (Atomic Force Microscopy, Scanning Tunneling Microscopy), Transmission Electron Microscopy, Scanning Electron Microscopy.

**Essential Reading:**

**Suggested Reading:**

### CH 3213 Chemical Reaction Engineering 4 Credits [3-1-0]

**Course Objective:** To enable students to apply the fundamental principles of chemical reaction kinetics to design different types of chemical reactors, to analyze the kinetic data, and to estimate kinetic parameters.

**Course Description:**

**Essential Reading:**

**Suggested Reading:**

### CH 3215 Processing & Handling of Materials 3 credits [2-1-0]

**Course objective:**
It covers almost all mechanical operations involved in industries and enables the students to understand the basic techniques in handling of materials such as screening, classification, sedimentation, filtration, coagulation, centrifugation etc. It educates the students to effectively utilize the knowledge gained to provide an economical method to process industries.

**Course Description:**

**Essential Reading:**
2. W I McCabe & J C Smith, P. Harriot, Unit Operations of Chemical Engineering, McGraw- Hill publication, 2005

**Suggested Reading:**

CH 3217 Chemical Process Technology 3 credits [3-0-0]

Course objective: This course provides the fundamentals to construct the flow diagram for any manufacturing process. It familiarizes the students with basic features of a flow chart.

Course Description:

Essential Reading:
1. C. E. Dryden, for the 21st century, (Edited & revised by M. G. Rao and M Sitting) 2006

Suggested Reading:

CH 3223 Chemical Engineering Thermodynamics and Reaction Engineering 3 credits [3-0-0]

Course Objective: To enable students to have a basic knowledge of chemical engineering thermodynamics and reaction engineering so that they can analyze the kinetic and thermodynamic data, and estimate the parameters in any reactive system.

Course Description:

Fundamentals of Chemical Reaction Engineering: Kinetics Reaction rate, order, rate constant; Kinetics of homogeneous single reactions. Ideal reactors: batch, stirred tank and plug flow systems; Conversion and yield in multiple reactions; non-isothermal reactors; Catalytic reactions: Catalytic rates, Reaction mechanisms; Internal/External transport in catalysts; Concept of RTD.

Essential Reading:

Suggested Reading:
1. Determination of average particle size of a mixture of particles by sieve analysis.
2. Study and operation of Jaw crusher and thereby verification of Ritinger's constant.
3. Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls.
4. Determination of the effect of no. of balls on grinding in a Ball mill and comparison of its critical speed with the operating speed.
5. To find out the effect of time on grinding and amount of undersize at zero time of grinding in a ball mill and to compare its operating speed with the critical speed.
6. To find out enrichment of the coal sample using a froth flotation cell.
7. Determination of the effectiveness of a vibrating screen.
8. To find the efficiency of Wilfley Table and the effect of water flow rate on efficiency of separation.
9. Study and operation of a Hammer mill thereby finding its reduction ratio.
10. Study and operation of a Pulverizer and thereby finding its reduction ratio.
11. Study and operation of a cyclone separator and thereby finding its efficiency of separation.
12. Study and operation of a Magnetic separator and thereby finding its efficiency of separation.
13. Study and operation of a Gyratory Crusher and thereby finding its reduction ratio.

CH 3251  Chemical Reaction Engineering Laboratory  1 Credits [0-0-2]

1. Study and operation of a packed bed reactor
2. Study and operation of a batch reactor
3. Study and operation of a CSTR
4. Study and operation of a plug flow reactor
5. Study and operation of a cascade CSTR
6. Study and operation of an adiabatic batch reactor
7. Study and operation Trickle bed reactor
8. Study and operation Condensation polymerization reactor
9. Study and operation Emulsion polymerization reactor
10. RTD study in a CSTR
11. RTD study in a plug flow reactor
12. Study and operation of a coiled tubular reactor.

CH 3253  Unit Operations Laboratory -II  1 credits [0-0-2]

Course Description:

1. Dynamics of a CSTR System.
2. Study of control value characteristics.
3. To find out the overall thermal conductance and plot the temperature distribution in case of a composite wall.
4. To find out the average heat transfer co-efficient in natural convection.
5. Determination of diffusivity of a naphthalene ball in air.
7. To find the effect of temperature on viscosity of the supplied samples of lubricating oil using Engler’s viscometer.
8. To find the Aniline point and Diesel Index of the supplied samples of liquid fuels
9. Determination of reduction ratio, maximum feed size and theoretical capacity of crushing rolls.
10. Determination of the effect of no. of balls on grinding in a Ball mill and comparison of its critical speed with the operating speed.
11. Study and operation of a plug flow reactor.
12. Study and operation of an adiabatic batch reactor.
13. Verification of Bernoulli’s Theorm.
14. Verification of Darcy’s Law.

CH 3310  Process Dynamics & Control  4 credits [3-1-0]

Course Objectives:

To equip the students with the knowledge of modelling a physical process, design various control schemes, apply the control system in various processes.
Course Description:
Control of Chemical Processes, Incentives and need of process control, design aspects and hardware for a process control system, Modeling the dynamic and static behaviour of chemical process, Need of mathematical modeling, Process modeling, Process variables and process degrees of freedom, state equations, Analysis of the Dynamic behaviour of chemical processes, Linearization, Laplace transforms, solution of linear differential equations using Laplace transforms, Transfer functions and input output model, Dynamic behaviour of first, second and other order and higher order systems, Analysis and design of Feedback control systems, concept and types of feedback control, measuring devices, final control element, block diagram, effect of various control action on processes, stability analysis, design of feedback controllers, frequency response analysis, Analysis and design of Advanced control systems, systems with large dead time and inverse response, control systems with multiple loops, feedforward and ratio control, adaptive and interfacial control systems, Multivariable processes, MIMO control system, interaction and decoupling of control loops, control systems for complete plant, Digital computer control loops, continuous to discrete system, z-transformation, discrete time response, design of digital feedback controllers.

Essential Reading:

Supplementary Reading:

CH 3314 CHEMICAL ENGG MATHEMATICS 3 credits [3-0-0]

Course Objective:
The foremost objective of this course is to introduce several computational techniques that are important in the solution of a variety of Mathematical problems that cannot be solved analytically. The sample problems will, for the most part of the course be taken from Chemical Engineering, though occasionally we will consider problems also from other related engineering areas. The methods and skills taught in this course will be valuable for future Chemical Engineering courses.

Course Description:
Treatment of engineering data: Numerical integration (Simpson, Trapezoidal and Gauss methods), Interpolation (Newton, Lagrange, Stirling), Empirical equations and least squares; Ordinary differential equations: Formulation of the physical problems for mass, energy, rate equations and flow systems. Solutions using analytical and numerical methods; Partial differential equations: Formulation of chemical engineering problems, Coordinate transformation, Solutions of partial differential equations using separation variable method and Fourier series and limited to two dimensional cases; Laplace transforms: Applications to Laplace transforms to simple chem. engg. problems.

Essential Reading

Suggested Reading:

CH 3316 PROCESS MODELING AND SIMULATION 3 credits [3-0-0]

Course objective:
Course Description:
Modeling: Fundamentals of mathematical models and formulation—Continuity equation, Equation of motion, Transport equations, Energy equation, Equations of state, Equilibrium, Chemical kinetics and their applications; Lumped and – distributed parameter models Fluid systems, C.S.T.R. (single, series, isothermal, constant hold up, variable hold up, gas phase pressurized and non-isothermal), Single component vaporizer, Multi-component flash drum, Batch reactor, Reactor with mass transfer, Ideal binary distillation column, Batch distillation, Heat exchanger, etc; Simulation: Numerical solution of Algebraic equation, ordinary differential equation, partial differential equation, simulation of single CSTR, multiple CSTR in series, single and multiple distillation column etc.

Essential Reading:

Suggested Readings:

CH 3317 PROCESS PLANT SAFETY 3 credits (3-0-0)

Course objective: Process engineers are equipped with modern tools and new techniques to keep the plant safe and free from hazards.

Course description:
Introduction, Toxicology, Industrial Hygiene, Source Model, Toxic Release and Dispersion Models, Fires and Explosions, Designs to Prevent Fires and Explosions, Introduction to Reliefs, Designing of Relief system, Probabilistic Risk assessment

Essential Readings

Suggested Readings

CH 3350 Process Dynamics & Control Laboratory 1 credits [0-0-2]

Course Objectives: The basic aim is to conduct experiments to acquire adequate knowledge to determine dynamics and control of various process parameters in different equipments.

Course Description:
1. Dynamics of First Order Systems.
2. Dynamics of non-interacting system in series.
3. Dynamics of interacting system in series.
5. Dynamics of a CSTR System.
6. Dynamics and Control of shell & tube heat exchanger.
7. Study of control value characteristics.
8. Study the performance of cascade control system.
9. Study of pressure Control system.
10. Study of PID Control Trainer.
11. Study of Ratio Control System.
13. Study of Multiprocess Control.
14. Study of Multivariable control system.
15. Study of Flow control system.

**CH 3414  ENVIRONMENTAL BIOTECHNOLOGY  3 credits [3-0-0]**

**Course Objective:** To equip the students with bioremediation and biological methods to keep the environment free from pollutants

**Course Description:**

**Essential Reading:**

**Suggested Reading:**

**CH 3415  COAL PROCESSING TECHNOLOGY  3credits [3-0-0]**

**Course objective:** To provide basic knowledge in coal preparation and processing technology

**Course Description:**
Role of coal in the overall energy situation; Recent advances in coal preparation methods including fine coal treatment; Simulation and modeling of coal beneficiation circuits ; Thermodynamics and kinetics of coal gasification reactions; Fluidized bed coal gasification processes; Combined cycle power generation; Coal liquefaction: Various methods, kinetics of solvent extraction, catalytic hydrogenation and other liquefaction processes; Concept of coal refinery and coalflex; Environmental impact analysis of coal utilization methods such as carbonization, gasification, etc.

**Essential Reading:**

**Suggested Reading:**
1. Mangold, Liquefaction and Gasification of Coal.
2. Wilson and Wales, Coal, Coke and Coal Chemicals.

**CH 3416  ENVIRONMENTAL ENGINEERING  3 credits [3-0-0]**

**Course objective:**
Air, water and solid waste disposal techniques will be studied and design of environmental control devices will be taken up.

**Course Description:**
Importance of environment for mankind, Damages due to environmental pollution; Air pollution: Introduction, Composition of air and nature of air pollution, Classification of pollutants
and their nature, Sources of air pollutants and their effects; Meteorological factors influencing air pollution, Methods of estimation of various types of pollutants in air, Air pollution problem in few typical chemical industries, Approaches to air pollution control, Control equipment for particulate emissions and gaseous pollutants, Pollution from mobile sources, Air quality criteria and standards; Water pollution: Waste water treatment – evaluation, classification of wastes, Control of water pollution, Characterisation of waste waters; Methods and equipment – preliminary treatment and disposal, Treatment of industrial wastes from a few typical chemical industries, Standards.

**Essential Reading:**


**Suggested Reading:**


**CH 3426 Fundamentals of Fuels and Combustion 3 credits [3-0-0]**

**Course Objectives:** The objective of this course aims at imparting basic knowledge of various types of fuels and their properties along with combustion chemistry to the students.

**Course Description:**

Origin of solid fuels, their compositions and classifications, coal characteristics, coal washing, coal storage, carbonization of coal, coal chemicals, Origin of liquid fuels, production of crude oil, Crude oil distillation, properties of various petroleum products, cracking, reforming, visbreaking processes, Origin and properties of natural gas, Synthetic liquid and gaseous fuels from solid fuels, Combustion calculations, Gas analysis and furnace design.

**Essential Reading:**


**Suggested Reading:**


**CH 3510 PETROLEUM REFINERY ENGINEERING 3 credits [3-0-0]**

**Course objective:** To enable the students to learn the fundamental and methodologies in the petroleum refining processes.

**Course Description:**


**Essential Reading:**


**Suggested Reading:**

CH 4117  FLUIDIZATION ENGINEERING 3 credits [3-0-0]

Course Objectives:
To have better understanding of fluidization phenomena, analyzing the behaviour associated with typical fluidized bed systems, develop generic models; investigate new diagnostic methods and analysis techniques to enable more reliable design and operation of industrial-scale fluidized bed systems.

Course Description:
Introduction to fluidization, types of fluidization, fluidization phenomena, historical development and industrial applications, Gross behaviour of fluidized beds, Minimum fluidizing velocity and pressure drops, Voidage, transport disengaging height, Distributor design, pressure drop requirement though distributor, behaviour in gas entry region, Bubbles in dense beds, Davidson Model, stream of bubbles, bubbling bed models, Emulsion phase, Turn-over rate of solids, residence time distribution diffusion model of solids movement, interchange coefficient into and out of wake, Entrainment and elutriation from fluidized beds, free board behaviour and entrainment from tall vessels, high velocity fluidization, turbulent and fast fluidized beds and associated pressure drop, Residence time distribution and size distribution of solids in fluidized beds, mixing and eggregation behaviour, particles of changing size; Circulation rates of solids, flow of high and low bulk density mixtures, Design for catalytic reactors; Design for noncatalytic gas-solid reactors.

Essential Reading:

Suggested Reading:

CH 4118  PARTICULATE SCIENCE & TECHNOLOGY 3 credits [3-0-0]

Course Objective:
To provide basic knowledge in particle size analysis, processing, particle formation, granulation, size reduction, fluid particle separation, safety and transport.

Course Description:
Study of particles: Definition of a particle, Qualities of particles, The industrial revolutions: explosion of particle related advances (from advanced mining techniques to abrasives, cutting tools, and mass production of chemicals and agricultural products). Modern scientific advances in paints and coatings and other particles in various base solvents, Particles in fluids; Composite materials, the design and manipulation of matter on the nanoscale and into nanostructures; Particle Science as an enabling technology to create new energy sources, clean our air and water and build stronger and lighter materials. Advances in particle sciences in particular in the area of human healthcare.

Essential Readings:
1. J.K. Beddow, Particulate Science and Technology

Suggested Reading:
2. M. Leva, Fluidization.

CH 4126  Introduction to Process Equipment Design 3 credits [3-0-0]

Course Objective: To help the students to design different chemical process equipments.

Course Description:
Material of Construction and lining of vessels. Design of storage tank, pressure vessel and vessel supports. Flanges and Nozzles. Design of Heat exchange Equipments such as shell and
tube heat exchanger, double pipe heat exchanger and evaporator. Design of separation equipments such as packed column and distillation column. Design of Dryer, Pipelines.

**Essential Reading:**

**Suggested reading:**

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**CH 4153 Process Equipment Design Laboratory 2 credits [1-0-2]**

**Course Objectives:** This course aims at imparting basic knowledge of design and simulation of Heat and Mass transfer equipments using ASPEN Plus/ASPEN HYSYS software

**Course Description:**
1. Calculation of bubble point and dew point of a feed mixture and distillate condensate. Estimation of T-x-y and P-x-y diagrams for both ideal and non-ideal solutions
2. Simulation of a binary distillation system using DSTWU and RadFrac simulators and estimation of optimum column conditions
3. Simulation of a multicomponent distillation system using DSTWU and RadFrac simulators and column sizing
4. Simulation of a trayed absorption column and sensitivity analysis
5. Simulation of a basic process flow sheet in pressure driven system
6. Dynamic simulation of a process with control actions
7. Design and simulation of heat exchangers: Shell and Tube, Plate type, Fin tube and double pipe
8. Design and simulation of a condenser
9. Design and simulation of a multiple effect evaporator system
10. Design and simulation of a stirred tank (jacketed and non-jacketed) for unsteady state heating and cooling of water

**Essential Reading:**

**Suggested Reading:**

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**CH 4212 Colloidal & Interfacial Science and Engineering 3 credits [3-0-0]**

**Course objective:** This course will provide a comprehensive overview on Colloids and Interfacial Engineering. Interfacial phenomena and colloidal systems have a wide range of application areas such as chemical, pharmaceutical, metallurgy, biotechnology, electronics and so on. Due to the interdisciplinary nature and wide applications in different areas, it is highly essential to give some basic idea on this subject

**Course Description:**
General introduction of colloids, interfaces, surfactants, and micellization.; Intermolecular forces, Van der Waals forces (Keesom, Debye, and London interactions), Colloidal systems and colloidal stability (van der Waals attraction and potential energy curves), Brownian motion and Brownian flocculation. Surface and interfacial tension and surface free energy, Surface tension for curved interfaces, Surface excess and Gibbs equation. Theory of surface tension and contact angle, and wetting. Thermodynamics of interfaces, thermodynamics of micelle and mixed micellarformation. Electrical phenomena at interfaces (Electrokinetic phenomena, Electrical double layer).

**Essential Reading:**

**Suggested Reading:**

**CH 4216**  
**Polymer Science & Technology**  
**3 credits [3-0-0]**

**Course Objective:**
To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior. Emphasis is on the processing techniques, along with the production of polymers. Towards the end, the student should be able to correlate structure-processing-properties relationships for polymers, blends and composites including nanocomposites.

**Course Description:**
Historical Background, Classification and forms of Polymers, Tactility, Functionality, Degree of Polymerization, identification of Polymers and end uses; Chemistry of Polymerization: Chain and Step Polymerization and their Kinetics Techniques of Polymerization: Bulk, Solution, Suspension and Emulsion Polymerization; Molecular Weight and its determination by Viscometry, Light-scattering and Osmometric methods; Crystallization in Polymers; Polymer Degradation; Manufacture and Uses of PF, UF, Vinyl Resins, Acrylic Resins, PS and PE; Polymer additives, Blends and Alloys; Polymer Processing; Plastics as materials of construction in chemical equipments.

**Essential Reading:**

**Suggested Reading:**
2. F. W. Billmeyer, Textbook of Polymer Science, John Willey & Sons

**CH 4313**  
**Applied Statistics for Chemical Engineers**  
**3 credits [3-0-0]**

**Course objective:** To enable the students will modern statistical tool for analysis of data.

**Course Description:**
Introduction to probability, distributions, moments, statistical inference estimation, variance and regression analysis. Statistical Process Control and Reliability, error analysis, pointestimation and confidence intervals, design of experiments, process monitoring based on statistical quality control techniques. Taguchi Approach, Case studies and use of Microsoft Excel.

**Essential Readings:**

**CH 4315**  
**Computational Fluid Dynamics**  
**3 Credits [3-0-0]**

**Course objective:**
- Provide an introduction to the field of computational fluid mechanics.
- Help students to develop an understanding of how numerical techniques like finite element and finite differences methods are devised and analysed with solution of fluid flow, heat transfer and mass transport problems as the target.
- Provide some experience in the software engineering skills associated with the implementation of these techniques in practical computer codes.
- Illuminate some of the difficulties encountered in the numerical solution of fluid flow problems.
**Course Description:**

Philosophy of computational fluid dynamics (CFD), review of equations governing fluid flow and heat transfer, simplified flow models such as incompressible, inviscid, potential and creeping flow.

Classification of partial differential equations, initial and boundary conditions, review of applied numerical methods.

Finite difference method: introduction, discretization method, consistency, error and stability analysis, fundamentals of fluid flow modeling.

Finite difference applications in heat conduction and convection: steady and transient heat conduction in rectangular and cylindrical geometries, convective heat transfer.

Solution of viscous incompressible flows by stream function-vorticity formulation; Solution of Navier-Stokes equation for incompressible flows using SIMPLE algorithm.

Finite Volume Method: Discretization methods, approximations of surface integrals and volume integrals, interpolation and differential practices, implementation of boundary conditions, application to the engineering problems.

**Essential Reading:**


**Suggested Readings:**


**CH 4317  PROJECT ENGINEERING  3 Credits [3-0-0]**

**Course Objective:**

To bridge the gap or the boundaries between engineering and project management, leading the technical workers who contribute to the building of structures or products.

**Course Description:**

Introduction to the subject; Development and implementation of the project, Process Design; Selection of process cycle; Chemical process considerations. Process flow sheet; Material balance and energy balance; Selection of process equipment and its computer aided design using Fortran language to various engineering problems; Plant layout: Planning layout and methods of layout planning; Economic evaluation of the project; Capital Cost; Plant cost estimation and Cost analysis with Break-even analysis. Total product cost: Manufacturing cost; Raw material cost; Miscellaneous cost (labour cost, repair cost and maintenance cost); Depreciation; Economic Analysis: Net earning profitability analysis, Optimization of batch process, continuous process, cyclic operations for fluid flow through pipe line, heat transfer through a heat exchanger & evaporator and mass transfer in an absorber and a distillation column.

**Essential Reading:**


**Suggested Reading:**

Course Objective:
To understand the need and origin of the optimization methods and to get a broad picture of the various applications of optimization methods used in process design.

Course Description:
Optimal problem formulation, Single variable optimization algorithms including interval halving; golden section search; Newton-Raphson method; bisection method; root finding using optimization techniques, Multi variable optimization algorithms including simplex search method; Cauchy s steepest descent method; Levenberg Marquardt s method, constrained optimization algorithms including Khun-Tucker conditions, transformation methods; direct search methods; liberalized search techniques; feasible direction method. Specialized algorithms including Integer programming; geometric programming. Non-traditional optimization technique like simulated annealing. Application of the aforesaid techniques in Chemical Engineering designs, like optimum insulation thickness, shell and tube heat exchanger design;

Essential Readings:

Suggested Readings:

CH 4351 Process Plant Simulation Laboratory 2 Credits [1-0-2]
Course content:
Simulate the manufacturing process of the given inorganic or organic chemical product using ASPEN Plus/HYSYS. Student has to first show the process flow sheet and discusses the modification in the process to simulate in ASPEN. Next he/she has to collect temperature, pressure and other necessary data required for all units in the plant to run the simulation. After flow sheet preparation and feeding all the necessary data in ASPEN student has to report the followings.
1. Material and energy balance around all units in the plant;
2. Overall yield;
3. Amount of energy required to run the plant;
4. Size of all equipments in the plant;
5. Magnitude of waste streams;
6. Optimization of individual units
7. Cost analysis.

CH 4352 Computational Fluid Dynamics Laboratory 2 Credits [1-0-2]
Course objective:
To understand and get familiar with the modeling of various flow phenomena commonly encountered in chemical engineering through numerical experimentation using commercial CFD package ANSYS FLUENT.
Course content:
Introduction to DesignModeller basic, sketching and modeling. generating a mesh, creating name selections, checking mesh quality, basic overview of using FLUENT interface, cell zone and boundary condition, fluid flow and heat transfer in a mixing tree, modeling flow around simple solid bodies (plat plate, cylinders, spheres etc.), modeling flow and heat transfer in a packed bed reactor, modelling uniform fluidization in 2D fluidized bed, turbulence flow in a compact heat exchanger.

CH 4418 Disaster Management in Chemical Industries 3 credits [3-0-0]
Course objective: To provide a firsthand knowledge in environmental management and disaster management with respect to typical case studies.
Course Description:
General aspects of industrial disaster: Due to fire, explosion, toxicity and radiation; Chemical hazards: Classification of chemical hazards, Chemical as cause of
occupational diseases – dust, fumes, gases and vapours; Hazard analysis and health management; Engineering control of chemical plant hazards – Plant layout, ventilation and lighting, Pressure vessels, Storage, Handling, Transportation, Electrical systems, Instrumentation; Emergency planning, Personal protective devices, Maintenance procedure; Emergency safety and laboratory safety; Legal aspects of safety, Management information system and its application in monitoring disaster, safety and health; Hazop Analysis.

Essential Reading:

Suggested Reading:

CH 4419 Energy Conservation & Renewable Sources of Energy 3 credits [3-0-0]

Course Objective:
To prepare students to know the overview of energy conservation and renewable energy systems.

Course Description:

Essential Reading:

Suggested Reading:

CH 4511 Separation Processes in Chemical Engineering 3 credits [3-0-0]

Course Objective:
To learn conceptual design of separation processes and design of equipment involved.

Course Description:
An overview: Separation techniques, separation from liquids, separation from gasses and vapors, separation from solids and separation methods in bioprocessing: aqueous two-phase separation, Reverse micelle extraction; Membrane separations: Definition of a
membrane and membrane process such as microfiltration, reverse osmosis, ultrafiltration, dialysis, electrodialysis, gas permeation, pervaporation Characterization of membrane such as colloidal morphology, permeability and permeselectivity. Membrane modules such as plate and frame device, spiral wound, tubular and hollow-fiber; Membrane technology in gas separation, biotechnology and in food and biochemical industry; Ion Exchange: Ion exchange mechanism, ion exchange media, equilibrium, equipment and design procedure and industrial applications; Adsorption as a separation process: Thermodynamics of adsorption: basic relationship, Representation, correlation and prediction of single component adsorption equilibrium data and extension to multi-component adsorption equilibrium calculation: Isotherm expression of gas adsorption; Adsorption with chemical reaction and adsorption with biological growth; Chromatography separation: Fundamentals of HPLC, Chromatographic column, Development of gradient-elution separations. Basic principles of capillary electro chromatography, mobile phase composition, Stationery phases used in CEC; Solid separation processes: Physical properties of solids, classification of powders, particle size distributions, particle density, bulk density and porosity, forces of adhesion. Separation of particulates and powders. Wet separation process: Protein recovery, Soya processing and other applications.

**Essential Reading:**

**Suggested Reading:**

**CH 4522 0 Fundamentals of Separation Process 3 credits [3-0-0]**

**Course Objective:**
To enable the students and equip them with Biochemical product separation and recovery: Membrane separation process, chromatographic method.

**Course Description:**
An overview: Separation techniques, separation from liquids, separation from gasses and vapors, separation from solids and separation methods in bioprocessing: aqueous two-phase separation, Reverse micelle extraction; Membrane separations: Types of membrane and its characterization methods, Preparation methods, design procedure and industrial applications; Adsorption: Preparation of adsorbate, Mechanism of adsorption process, Isotherms, Batch and Continuous adsorber, Design of adsorber, Industrial applications, Thermodynamics of adsorption process, Extraction process: Types and Application; Leaching process: Types and Applications; Fundamentals of HPLC analyzer.

**Essential Reading:**

**Suggested Reading:**
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<th>Sl.No.</th>
<th>Sub. Code</th>
<th>Subject</th>
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<td>CR-2401</td>
<td>Unit Operations in Ceramic Processing</td>
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<td>22</td>
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<td>CR-3203</td>
<td>Instrumental Characterization Lab</td>
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<td>CR-3403</td>
<td>Refractory Lab</td>
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<td>21</td>
<td>CR-3205</td>
<td>MATLAB and simulink</td>
<td>0-0-2</td>
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<td>22</td>
<td>CR-3408</td>
<td>Glass Lab</td>
<td>0-0-3</td>
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<td>23</td>
<td>CR-3410</td>
<td>White ware technology Lab</td>
<td>0-0-3</td>
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<td>24</td>
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<td>CR-4103</td>
<td>Mechanical Testing Lab</td>
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<td>26</td>
<td>CR-4105</td>
<td>Ceramography and microscopy lab</td>
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<td>CR-4304</td>
<td>Electro ceramics Lab</td>
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<td>Finite Element Lab</td>
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<td>CR-3103</td>
<td>Application of phase diagram</td>
<td>3-0-0</td>
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<td>30</td>
<td>CR-3105</td>
<td>Heat transfer and fluid flow</td>
<td>3-0-0</td>
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<tr>
<td>31</td>
<td>CR-3301</td>
<td>Functional Materials and devices</td>
<td>3-0-0</td>
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<td>32</td>
<td>CR-3414</td>
<td>Unshaped refractories</td>
<td>3-0-0</td>
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<td>33</td>
<td>CR-3416</td>
<td>Metallurgical processes</td>
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<td>34</td>
<td>CR-3202</td>
<td>Interface Science &amp; Sol-gel processing</td>
<td>3-0-0</td>
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<td>35</td>
<td>CR-4201</td>
<td>Nanoceramics</td>
<td>3-0-0</td>
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<td>36</td>
<td>CR-4203</td>
<td>Bioceramics</td>
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<td>37</td>
<td>CR-4401</td>
<td>Industrial Applications of Refractories</td>
<td>3-0-0</td>
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<td>38</td>
<td>CR-4205</td>
<td>Composite materials</td>
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<td>39</td>
<td>CR-4207</td>
<td>Porous ceramics</td>
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<td>40</td>
<td>CR-4403</td>
<td>Ceramic Equipment Design</td>
<td>3-0-0</td>
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<td>41</td>
<td>CR-4402</td>
<td>Waste management of ceramic industries</td>
<td>3-0-0</td>
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<tr>
<td>42</td>
<td>CR-4102</td>
<td>Tribology of Materials</td>
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<td>43</td>
<td>CR-4204</td>
<td>Ceramic coating</td>
<td>3-0-0</td>
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<tr>
<td>44</td>
<td>CR-4306</td>
<td>Ceramics in energy sector</td>
<td>3-0-0</td>
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<td>45</td>
<td>CR-4308</td>
<td>Optical Ceramics</td>
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<td>46</td>
<td>CR-4404</td>
<td>Industrial furnace design</td>
<td>3-0-0</td>
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<tr>
<td>47</td>
<td>CR-0001</td>
<td>Introduction to ceramics</td>
<td>3-0-0</td>
<td>3</td>
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<tr>
<td>48</td>
<td>CR-0002</td>
<td>Properties of Ceramics</td>
<td>3-0-0</td>
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<td>49</td>
<td>CR-0003</td>
<td>Ceramic fabrication</td>
<td>3-0-0</td>
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<td>50</td>
<td>CR-0004</td>
<td>Industrial Ceramics</td>
<td>3-0-0</td>
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<td>51</td>
<td>CR-0005</td>
<td>Ceramic testing and characterization</td>
<td>3-0-0</td>
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<td>52</td>
<td>CR-0006</td>
<td>Advanced Ceramics</td>
<td>3-0-0</td>
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</table>
Course Description:

Essential Reading:

Supplementary Reading:

Course Description:
Availability, properties and important applications of naturally occuring raw materials: Bauxite, Limestone, Chromite, Magnesite, Dolomite, Fluorite, Graphite, Gypsum, Haematite, Kaolinite, Fireclay, Ball clay, Montmorillonite, Magnetite, Nepheline Syenite, Microcline, Feldspars (soda, potash, lime), Pyrophyllite, Quartz, Quartzite, Sillimanite, Kyanite, Andalusite, Talc, Wollastonite, Zircon, Beryl, Mica, Vermicullite, Silica sand etc ; Brief idea on processing of synthetic raw materials: Bayer process alumina, Calcined Alumina, Tabular Alumina, Fused Alumina, Sea-water Magnesia, fused magnesia, Zircon and Zirconia, Titania, Magnesio-Aluminate Spinel, Fumed Silica etc. The application areas and limitations of synthetic raw materials; Effect of heat on different raw materials with reference to phase transformation, thermal expansion, melting, decomposition behaviour, compound formation, stabilization.

Essential Reading:

Supplementary Reading:
Course Description:
Introduction, concept of states, systems equilibrium. Equation of states, extensive and intensive properties homogeneous and heterogeneous systems. Internal energy, heat capacity, enthalpy, isothermal, and adiabatic processes; Second law of thermodynamics, entropy, enthalpy concepts, degree of reversibility and irreversibility, criteria of equilibrium, auxiliary functions, combined statements, Maxwell’s relations, transformation formula, Gibbs-Helmoltz equation; Concept of Third law, temperature dependence of entropy, statistical interpretation of entropy, Debye and Einstein concept of heat capacity, relation between $C_p$ and $C_v$; Fugacity, activity, equilibrium constant, homogeneous and heterogeneous equilibria. Ellingham-Richardson diagrams and applications; Solution thermodynamics, partial molal quantities, ideal and non-ideal solutions, Henry's law, Gibbs - Duhem equation, regular solution, quasi-chemical approach to solution; Statistical thermodynamics. Change of standard state. Phase equilibrium and phase rule.

Essential Reading:

Supplementary Reading:

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<th>Course Caretaker</th>
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</thead>
<tbody>
<tr>
<td>CR-2102</td>
<td>Structure and Phase equilibrium in ceramics</td>
<td>3</td>
<td>Prof. S. K. Pratihar</td>
</tr>
</tbody>
</table>

Course Description:
Bonding and structure of materials, Crystal Structure and Crystal Geometry: Space lattice; Unit cells; Crystal systems; Bravis lattices; Miller indices; Volume, planar and linear density unit cell calculations; Polymorphism; Crystal structure analysis, Crystalline Imperfections, defect chemistry. Some Real Structures: Rock Salt, Zinc Blende, Antifluorite, Rutile, Perovskite, Spinel, Wurtzite etc. Crystal imperfections: types and notations, Solid solutions, defects and dislocations. Vitreous state, glasses and structural models; Condensed phase rule and single component system: Silica, Zirconia and Carbon etc. Two component systems and Lever rule. Free energy-composition diagrams, phase stability, solid solutions, Eutectic and Eutectoid, Peritectic reaction, congruently and incongruently melting compound. Some important binary ceramic systems $\text{SiO}_2$-$\text{Al}_2\text{O}_3$, $\text{MgO}$-$\text{Al}_2\text{O}_3$, $\text{CaO}$-$\text{SiO}_2$, $\text{CaO}$-$\text{ZrO}_2$, $\text{MgO}$-$\text{SiO}_2$, $\text{BaO}$-$\text{TiO}_2$, $\text{CaO}$-$\text{Al}_2\text{O}_3$, $\text{CaO}$-$\text{MgO}$; Ternary System: Representation of composition on triangle, proof of the basis, Temperature, Solid models, Iso-thermal Sections, Base projection method. Ternary systems with binary and ternary Eutectic, Peritectic, congruently and incongruently melting compounds. Some important ternary ceramic systems: $\text{CaO}$-$\text{SiO}_2$-$\text{Al}_2\text{O}_3$, $\text{MgO}$-$\text{SiO}_2$-$\text{Al}_2\text{O}_3$, $\text{CaO}$-$\text{MgO}$-$\text{SiO}_2$. Brief idea on the application of real system binary, ternary and quaternary phase diagrams in the processing and process control of different ceramic materials.

Essential Reading:

Supplementary Reading:
### Course Description:

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### Supplementary Reading:


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<td>CR-2106</td>
<td>High temperature processes in ceramics</td>
<td>3</td>
<td>Prof. S. K. Behera</td>
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Course Description:

Essential Reading:

Supplementary Reading:

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<tbody>
<tr>
<td>CR-3101</td>
<td>Physical Ceramics: Properties</td>
<td>3</td>
<td>Prof. S. K. Pratihar</td>
</tr>
</tbody>
</table>

Course Description:
Mechanical Properties: Concept of strength and its relation with fundamental parameters, plastic deformation, viscous flow, creep, Fracture of materials; Thermal Properties: Thermal expansion, thermal shock, annealing and chemical strengthening, specific heat and heat capacity, thermal conduction process; Electrical Properties: Electrical, electronic and ionic conduction phenomena in crystals, Fast ionic conductors, glasses and non-stoichiometric compounds. PTCR, NTCR, Varistors, thermisters etc; Dielectric Properties: Dielectric loss of crystals and glasses, dielectric strength, piezoelectric and ferroelectric ceramics; Magnetic Properties: Concept of magnetic phenomena in solids. Structure and magnetic properties of spinel ferrites, rare-earth garnets, ortho-ferrites and hexagonal ferrites with special reference to their microstructure; Optical Properties: Refractive index and dispersion, reflectance, opacity and translucency, absorption and colour from modern concepts in crystalline and vitreous ceramic systems.

Essential Reading:
Supplementary Reading:

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<tr>
<td>CR-3401</td>
<td>Refractory Technology</td>
<td>3</td>
<td>Prof. R. Sarkar</td>
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**Course Description:**

**Essential Reading:**

Supplementary Reading:

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<tr>
<td>CR-3201</td>
<td>Instrumental Characterization</td>
<td>3</td>
<td>Prof. B. B. Nayak</td>
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**Course Description:**

**Essential Reading:**


**Supplementary Reading:**


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<tr>
<td>CR-3402</td>
<td>Glass technology</td>
<td>3</td>
<td>Prof. S. K. Pal</td>
</tr>
</tbody>
</table>

**Course Description:**

**Essential Reading:**

2. P.J. Doyle, Glass Making Today, Cbls\Ceramic Books & Literature, 2000


**Supplementary Reading:**


<table>
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<tr>
<td>CR-3404</td>
<td>Whiteware Technology</td>
<td>3</td>
<td>Prof. S. Bhattacharyya/Prof. S. K. Pal</td>
</tr>
</tbody>
</table>

**Course Description:**
Raw materials, processing, properties, batch composition and the effect on the properties of whiteware bodies, effect of particle size distribution of kaolinite on plasticity and workability of clay. Rheology and properties of clay - water system, mechanism of plasticity, additives/binders, plasticizers, flocculants and deflocculants and slip properties; Classification of whiteware bodies, batch formulation Tri-axial bodies - porcelain, stoneware, earthenware, hotel ware, majolica, terra-cotta, bone china, parian-art ware, insulator, tiles, sanitary ware etc. Body preparation including the unit operations and fabrication processes. Application of granular mechanics to slip casting. Influence of particle size distribution on properties of fired whiteware bodies. Mould materials, mould and mould design; Fundamentals of drying and
shrinkage. Firing of whiteware bodies, microstructure evolution during firing of whiteware bodies. Time, temperature and atmosphere effects on firing of whitewares, special firing techniques, Glaze structure, formulation, raw materials, batch calculation, preparation, slip rheology, application. colours, decoration firing. Testing of white ware bodies.

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-3406</td>
<td>Cement Technology</td>
<td>3</td>
<td>Prof. J. Bera</td>
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**Course Description:**

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-4101</td>
<td>Structural Ceramics</td>
<td>3</td>
<td>Prof. S. Bhattacharyya</td>
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</table>

**Course Description:**
Introduction and classification of Structural Ceramics, Mechanical behavior of ceramics, Theory of brittle fracture, Cracking in brittle materials, Physics of the fracture of brittle solids, Basic mechanical properties, Statistical nature of strength, Alumina and alumina ceramics, Crystal structure, phases, types of alumina, properties and its relation to microstructure, importance and application. Zirconia Ceramics Crystal structure and polymorphic modifications, Transformation Toughening; different system in zirconia, application. Composites: strengthening and toughening mechanisms, composite fabrication. Composites of some oxides and nonoxides. Classification of non-oxide ceramics, silicon carbide, silicon nitride, Sialon, Tungsten Carbide, Boron Carbide, Boron Nitride, Carbon and Graphite, phase diagrams,
processing, sintering and properties. Abrasives; natural and synthetic; properties, applications and performances; Surface and subsurface stress distributions and Hertzian contact; Contact between solid surfaces; Adhesion Friction; Testing, Frictional behavior (Solid – solid contact, liquid mediated contact), Friction mechanism of metals, ceramics and polymers, solid lubricants. Thermal properties of sliding surfaces; Classification of wear and wear testing, role of humidity; the various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidizing (mild and severe), melt and the wear-mechanism maps, types of particle present in wear debris; Surface Engineering, Methods to reduce wear and performance enhancement.

Essential Reading:

Supplementary Reading:

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<tbody>
<tr>
<td>CR-4302</td>
<td>Electro ceramics</td>
<td>3</td>
<td>Prof. R. Mazumder</td>
</tr>
</tbody>
</table>

Course Description:
Definition, classification, scope and market. Insulators and dielectrics: low-loss ceramics, ceramic capacitors, ferroelectricity in capacitor technology, disk capacitor, MLC, barrier - layer capacitor; processing, properties and application areas. Piezoelectric and electro-optic ceramics: Fundamental properties, materials, processing, and application areas. Pyroelectric Ceramics: Fundamental properties, materials, processing and application areas. Voltage dependent resistors, Ceramic based chemical sensor, Fuel cell Batteries: Fundamental knowledge on electronic and ionic conduction in ceramic system, Materials issues, processing, Electrical characteristics and applications. Ferrites: Materials, processing, properties and application areas. Ceramic superconductors: Materials, processing, properties and application areas.

Essential Reading:

Supplementary Reading:

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<tr>
<td>CR-2405</td>
<td>Unit Operations Lab</td>
<td>1</td>
<td>Prof. A. Chowdhury</td>
</tr>
</tbody>
</table>

List of experiments:
1. Sieve analysis and particle size distribution of milled/crushed product.
2. Verification of Rittinger’s Crushing Law and determination of crushing efficiency of Jaw Crusher.
3. Validation of Bond’s Law and determination of crushing efficiency of Roller Crusher.
4. Determination of angle of nip and maximum feed size for Roll Crusher.
5. Determination of critical speed and crushing rate of Ball Mill.
6. Operation of Counter Current Mixer and determination of mix consistency.
7. Study and operation of Hydraulic Press and determination of bulk density.
8. Drying sensitivity of clay body.

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<tr>
<td>CR-2410</td>
<td>Chemical Analysis Lab</td>
<td>1</td>
<td>Prof. Sunipa Bhattacharyya</td>
</tr>
</tbody>
</table>

List of Experiments:
1. Determination of CaO and MgO present in a salt solution by EDTA method.
2. Quantitative estimation of silica and mixed oxide (iron oxide and aluminium oxide) present in a cement sample.
3. Determination of alkali content of a ceramic sample by flame photometer.
5. Analysis of chromite ore by acid fusion method.
6. Preparation of Precipitated Silica/silica gel and determination of its moisture absorption capacity.
7. CEC of Zeolite at different temp / Determination of CEC of a clay sample.
10. Complete Chemical analysis of clay/magnesite/bauxite following Na₂CO₃/NaOH fusion.

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<tr>
<td>CR-2108</td>
<td>High temperature processing lab</td>
<td>1</td>
<td>Prof. S. K. Pratihar</td>
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</tbody>
</table>

List of Experiments:
1. Study and operation of an electrical laboratory furnace.
2. Calibration of thermocouple and determination of temperature profile of the furnaces.
3. Effect of process parameters on the response behaviour of PID controller.
4. Calibration of PID temperature Controller.
5. Study of isothermal sintering behaviour of ceramic materials.
7. Densification kinetics study using constant rate heating sintering.
9. Study of the heating rate on constant rate heating densification behaviour.

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<tr>
<td>CR-3203</td>
<td>Instrumental Characterization Lab</td>
<td>1</td>
<td>Prof. B. B. Nayak</td>
</tr>
</tbody>
</table>

List of Experiments:
2. Study of reversible phase transition in quartz.
3. Weight loss behaviour of dolomite, magnesite and limestone by TGA.
4. Study of thermal expansion behaviour and determination of thermal expansion coefficient of ceramic product.
5. Determination of thermal hysteresis of zirconia by dilatometric method.
7. Indexing of cubic crystal system and determination of its lattice parameter.
9. Determination of crystallite size from x-ray line broadening.
10. Study of data acquisition and processing for obtaining an x-ray profile.
11. Phase identification using software.

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<td>CR-3403</td>
<td>Refractory Lab</td>
<td>1</td>
<td>Prof. R. Sarkar</td>
</tr>
</tbody>
</table>

List of Experiments:
1. Determination of packing density of one component system of various particle sizes.
2. Determination of packing density of two component system having various size ratios.
3. Recipe calculation and recipe making for refractory mix.
5. Shaping of refractory brick by dry pressing/hand moulding method.
6. Determination of porosity and density of the prepared refractory brick.
7. Determination of crushing strength of refractory bricks.
10. Vibrocasting of supplied castable and study of cured property.
11. Effect of casting parameter on the properties of cast refractories.
12. Study of strength development of castable with temperature.

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<tbody>
<tr>
<td>CR-3205</td>
<td>MATLAB and simulink</td>
<td>1</td>
<td>Prof. S. K. Pal/Prof. P. Saha</td>
</tr>
</tbody>
</table>

List of Experiments
1. Introduction to matlab software interfaces and different tools
2. Variables and expressions
3. Vectors, Matrices, Multiple vector plots
4. Command and Scripts, Managing Data files, Developing functions
5. Logic and flow control
6. Data analysis
7. Creation and simulation of models
8. Programming for a modeling
9. Modeling discrete and continuous system
10. Solver Selection
11. Modeling Conditionally Executed algorithms and combining models and diagrams
12. Creating libraries

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<tr>
<td>CR-3408</td>
<td>Glass Lab</td>
<td>1</td>
<td>Prof. S. K. Pal</td>
</tr>
</tbody>
</table>

List of experiments:
1. Batch calculation and preparation of soda-lime-silicate glasses (Use of coloring agents, refining agent)
2. Polishing of glass plates and quantitative flatness measurement using monochromatic light
3. Determination of Littleton softening point of glass using fiber elongation viscometer
4. Determination of Annealing point and strain point of glass
5. Study of chemical durability of glasses using Flame Photometer
6. Determination of refractive index and Abbe value of glass in different wavelength
7. Determination of density of glass by sink and float method
8. Determination of residual stress and Birefringence in glass using polarimeter
9. Thermal tempering of glass and mechanical property measurement
10. Chemical tempering of glass and mechanical property measurement
11. Determination of Absorption of light and use of spectrophotometer for qualitative and quantitative analysis of glass.
12. Fabrication of hollow glass ware by blowing techniques

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<tbody>
<tr>
<td>CR-3410</td>
<td>Whiteware technology Lab</td>
<td>1</td>
<td>Prof. A. Paul</td>
</tr>
</tbody>
</table>

**List of Experiments**

1. Design and drawing of model and mould.
2. Shaping of a pre-designed plaster model.
3. Fabrication of pre-designed slip casting mould.
4. Fabrication of model using Jigger and Jolly
5. Determination of plasticity and Plasticity Index.
7. Study of drying curve and critical moisture content of a green body.
8. Determination of vitrification range of a whiteware body.
10. Study of slip casting behaviour.
11. Study of glaze-body fit by dilatometer
12. Determination of flow limit of glaze
14. Crazing resistance of glazed article.

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<th>Course Caretaker</th>
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<tbody>
<tr>
<td>CR-3412</td>
<td>Cement Technology Lab</td>
<td>1</td>
<td>Prof. J. Bera</td>
</tr>
</tbody>
</table>

**List of Experiments**

1. Preparation of Portland cement in the laboratory
2. Determination of consistency of cement.
3. Study of initial and final setting of cement by Vicat apparatus.
5. Making and curing of cement mortar.
6. Compressive strength of cement mortar fine with ageing time.
7. Determination of surface area of cement by Blain Air Permeability apparatus.
8. Determination of fineness modulus and grain size distribution of fine aggregate.
9. Effect of casting process parameters on the properties of cement mortar.
10. Quantitative chemical analysis of cement.
11. Effect of admixture on cement mortar
12. Study of the durability of cement mortar

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<tbody>
<tr>
<td>CR-4103</td>
<td>Mechanical Testing Lab</td>
<td>1</td>
<td>Prof. A. Paul</td>
</tr>
</tbody>
</table>

**List of experiments**

1. Load deformation curve of brittle/ductile materials
2. Flexural strength of materials by three point bending
3. Flexural strength of materials by four point bending
4. Flexural strength of materials by Brazilian test
5. Indentation hardness of ceramic materials
6. Wear testing of ceramics
7. Fatigue test of ceramic materials
8. NDE of ceramics
## List of experiments

1. Ceramography specimen preparation I: Sectioning and sawing, mounting of samples.
2. Ceramography specimen preparation II: Grinding, polishing, lapping, etching.
4. Quantitative ceramography: Grain size determination, shape, anisotropy, porosity and second phase calculation.
5. Qualitative ceramography: Phase determination, fractography, and orientation.
6. Microscopy of oxide ceramics: Alumina, Zirconia, Spinel
7. Microscopy of industrial ceramics: Refractories, triaxial bodies,
8. Microscopy of non-oxide ceramics: Silicon carbide, silicon nitride, boron carbide, SiAlION

## List of Experiments:

1. Determination of frequency dependent dielectric constant and loss-factor of capacitors.
2. Determination of temperature coefficient of capacitance (TCC) and polymorphic phase transition temperature (if any) of linear dielectrics and nonlinear dielectrics.
3. Measurement of breakdown strength of dielectric at room temperature and at elevated temperature.
4. Poling of ferroelectric ceramic and measurement of piezoelectric voltage and charge coefficient
5. Measurement of Electromechanical coupling coefficient and Mechanical quality factor
6. Measurement of polarization-electric field (P-E) of different dielectric materials by sawer-tower cuircuit.
7. Study of grain and grain boundary resistivity/capacitance by Impedance analysis.
8. Determination of B-H curve, permeability and magnetic loss of ferrite.
9. Determination of magnetic Curie temperature.
10. Temperature dependent conductivity of insulators/ semiconductors/conductor and arrhenius plot for determination of activation energy of conduction.
11. I-V characteristics of varistors.
12. Taffel plot for anodic and cathodic polarization.

## Course Description:


## Essential Reading:

Supplementary Reading:

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</thead>
<tbody>
<tr>
<td>CR-3103</td>
<td>Application of phase diagram</td>
<td>3</td>
<td>Prof. J. Bera</td>
</tr>
</tbody>
</table>

Course Description:
Some important three component systems- CaO–Al₂O₃ –SiO₂, MgO-Al₂O₃-SiO₂, SiO₂-FeO-Fe₂O₃, MgO-FeO-Fe₂O₃, MgO-Al₂O₃-Cr₂O₃. Quaternary System- MgO-CaO-SiO₂-Fe₂O₃, MgO-SiO₂-CaO-B₂O₃. The relevance of above phase diagrams in the ceramic system. Use of phase diagram in the sintering of ceramics; multiphase system containing a liquid phase, tungsten-carbide-cobalt system, porcelain, silicon nitride. Crystal growing techniques and use of phase diagrams in crystal growth; growth from stoichiometric melts, impurity distribution coefficient, constitutional supercooling and non-stoichiometric melts, single crystal growing of Yttrium-iron-garnet, cubic barium-titanate, gallium-phosphide, quartz crystal from hydrothermal solution; Phase diagrams in the development and use of refractories; Alumino-silicates, Silica and basic refractories, Fusion cast refractories. Liquid immiscibility in oxide systems. Study of dissolution of refractories in molten slag; Application of the phase diagrams in cement chemistry; calcium-aluminate cement and Portland cement
Phase diagrams in glass making, iron-carbon system, in the stabilization of zirconia phases. Phase diagrams in high pressure systems, recent developments in this area.

Essential Reading:
3. A. M. Alper (Editor), G. Kostorz (Series Editor), H. Herman (Series Editor), Phase Diagrams in Advanced Ceramics, Treatise on Materials Science and Technology Academic Press. 1995.

Supplementary Reading:

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<tbody>
<tr>
<td>CR-3105</td>
<td>Heat transfer and fluid flow</td>
<td>3</td>
<td>Prof. P. Saha</td>
</tr>
</tbody>
</table>

Course Description:
Fluid properties, density, viscosity, surface tension, compressibility. Classification of fluids: Newtonian and non-Newtonian fluids. Equation of continuity for compressible and incompressible fluid flow, Bernoulli’s equation and its practical applications. Flow measurements: Venturimeter, Orifices, Pitot tube and Rotameter. Significance of Reynolds, Numbers; Pressure drop in flow and pressure drop calculation in various cases, Hagen–Poiseuille equation, Flow through bends, Straight and bend pipes, Packed beds, Fluidized bed. What is Vacuum, Classification of Vacuum Ranges, Gas flow in vacuum system, Production of Vacuum, Measurement of Vacuum systems, Steady state and unsteady state conduction. Heat flow through composite walls, cylinders and spheres, Thermal resistances in series and parallel for ceramic materials. Convective heat transfer: Free and forced convection, application of dimensional analysis to convection problems. Significance of Nusselt, Grashof, Reynolds, and Prandtl Numbers; Euler’s numbers, Radiation Heat Transfer through black body and grey body,

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-3301</td>
<td>Functional Materials and devices</td>
<td>3</td>
<td>Prof. R. Mazumder</td>
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**Course Description:**

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-3414</td>
<td>Unshaped refractories</td>
<td>3</td>
<td>Prof. R. Sarkar</td>
</tr>
</tbody>
</table>

**Course Description:**
Introduction to monolithic refractories, advantages and disadvantages; classifications based on application techniques, chemical constituents and purity; raw materials and their selection, particles size distribution, discrete and continuous particle size distribution, Furnas, Andreassen-Andersen and Dinger-Funk model; different bonding systems, CaO-Al2O3 system, hydration of calcium aluminates, bonding mechanism of different binders, various additive systems; refractory castable and details of CCC, LCC, ULCC, NCC, SFC; other monolithics, like mortar, gunning mass, spraying mass, ramming mass, etc; machinery and equipments for making unshaped refractories, batch preparation, mixing, processing and manufacturing techniques; installation techniques and application; properties and specialties of different castable systems, like alumina, alumina - magnesia, alumina spinel, magnesia, magnesia carbon, etc
Essential Reading:

Supplementary Reading:

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<tr>
<td>CR-3416</td>
<td>Metallurgical processes</td>
<td>3</td>
<td>Prof. P. Saha</td>
</tr>
</tbody>
</table>

Course Description:
Structure of Metals and Alloys; Solid Solutions; theory of point defect (Schottky and Frenkel), line defect (dislocation), and stacking fault, Lomer-Cottrell lock, Peierls-Nabarro stress, Critical resolved shear stress (CRSS), Strengthening mechanisms of metals and alloys, Metallurgical Kinetics; homogeneous and heterogeneous reactions; Chemical Reaction Control-rate equation, reaction rate constant, reaction order, non-elementary reactions; Diffusion; Pyrometallurgical operations; Principles of Hydro Metallurgy and Electro Metallurgy for aluminium, copper and zinc; Iron making; Blast Furnace Iron Making: Recent advances in Iron Making; Sponge iron making; Steel Making: secondary steelmaking deoxidation, ladle and tundish metallurgy, ingot and continuous casting of steel; Recovery, Recrystallization and grain growth, Iron-Carbon phase diagram, eutectoid transformations in carbon-steels, TTT diagram, CCT diagram, Heat treatment of steel - Annealing, Normalizing, Quenching, Carburizing, Case-Hardening, hardenability, tempering of martensite; Gas-solid and slag-metal reactions; Non Ferrous Metallurgy (Aluminium, Copper, Zinc, Titanium); Non Secondary metals and utilization of wastes.

Essential Reading
5. T. Courtney, Mechanical Behavior of Materials, Waveland Press, Technology & Engineering
6. G. Dieter, Mechanical Metallurgy, McGraw-Hills

Supplementary Reading

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<tr>
<td>CR-3202</td>
<td>Interface science &amp; Sol-gel processing</td>
<td>3</td>
<td>Prof. A. Chowdhury</td>
</tr>
</tbody>
</table>

Course Description:
Thermodynamics of surface. Adsorption Isotherm. Physical aspects of interfaces, Grain boundary, Contact angle, Dihedral angle and Grain shape prediction, Concept of wetting. Structure of surface and interface; Colloids, Sols and gels, Types of colloids; attractive surface
forces, stabilization of colloids, Electrostatic stabilization, charge development on the particle surface in aqueous medium, origin of electrical double layer, Iso-electric points and zeta potential, Effect of electrolytes on double layer, Ion exchange capacity and exchange equilibrium, adsorption of polymers and steric stabilization, electrosteric stabilization, structure of consolidated colloids, Rheology of consolidated colloids, Flocculation and de-flocculation phenomena, kinetics of flocculation; Wetting agents, Plasticizers, Foaming and antifoaming agents, Lubricants; Types of gel, sol-gel processing of aqueous silicates, metal alkoxides, hydrolysis and condensation, effect of pH on gelation, aging, drying and gel densification. Sol-gel preparation technique, single and multi-component gel, use of double alkoxides, applications of sol-gel processing.

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-4201</td>
<td>Nanoceramics</td>
<td>3</td>
<td>Prof. B. B. Nayak</td>
</tr>
</tbody>
</table>

**Course Description:**
Introduction to nanotechnology: Formation of nanomaterials by size reduction: Amorphisation by milling, molten drop impingement and limitations of milling for ceramic materials. Gas phase processes for nanomaterial synthesis: Nanosized clusters of elementary particles and ceramic materials. Condensed phase processes for nanomaterial synthesis: Manufacture of nanostructured materials (densification, nanocomposites). Determination of structure and chemical, mechanical, magnetic, electrical and optical physical properties of nanomaterials. Methods for determination of particle size, porosity, specific surface, chemical and supramolecular structures at the nanometric level. Proximal microscopies (AFM and STM), nanolithography and nanofabrication; technological applications of nanomaterials- superplasticity, plastic flow processing of ceramics; ultra-pure and biocompatible ceramics; gas sensors; transparent ceramic coatings, diamond-like coatings, the fullerenes and carbon nanotubes, nano magnets for sensors and high density data storage, spin-tronic devices, nanotechnology for biological system & bio-sensor applications.

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-4203</td>
<td>Bioceramics</td>
<td>3</td>
<td>Prof. S. Dasgupta</td>
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**Course Content**

Essential Reading

Supplementary Reading

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<tr>
<td>CR-4401</td>
<td>Industrial Applications of Refractories</td>
<td>3</td>
<td>Prof. R. Sarkar</td>
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Course Description:

Essential Reading:

Supplementary Reading:

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<tr>
<td>CR-4205</td>
<td>Composite materials</td>
<td>3</td>
<td>Prof. A. Paul/Prof. A. Chowdhury</td>
</tr>
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</table>
Course Description:
Composites- Definition, Classification and Importance, design of composite materials, the concept of load transfer, Glass, ceramic and carbon fibres, silicon carbide, alumina and alumino-silicate fibres. Common ceramic matrix material and their properties, interfaces in composites, interaction at the interface. Types of reinforcement: continuous fibre, short fibre, whisker ; Ceramic Matrix composites: fibre packing arrangement, fabrication, properties, interface reaction, toughness ; specific examples - Alumina -silicon carbide, Mullite- Zirconia, polymer-PZT composites, metal composites, layered composites- composite processing, densification and application ; properties of composites: Density, Mechanical properties, mechanism of load transfer from matrix to fibre, elastic deformation of laminates, variation of lamina properties with orientation, tensile and compressive strength and failure mechanism of long and short fibre composites, toughness of composites and sub-critical crack growth, thermal behaviour of composites debonding, fibre pull out, delamination fracture. Application of composites. Recent advances in composite technology, recent developments in this area.

Essential Reading:

Supplementary Reading:

Sub. Code. | Course Name         | Credit | Course Caretaker
---        |---------------------|--------|----------------
CR-4207   | Porous ceramics     | 3      | Prof. S. K. Behera/ Prof. Sunipa Bhattacharyya

Course Description:

Essential Reading:
2. Mechanics and Physics of Porous Solids; Olivier Coussy; Willey Publication; 2010;

Supplementary Reading:
1. Advances in Porous Ceramics; Alan Newton; Nova Science Publishers Inc (Verlag);2017
2. Porous Materials; Duncan W. Bruce (Editor), Dermot O'Hare (Editor), Richard I. Walton (Editor); Wiley;2011

Sub. Code. | Course Name                  | Credit | Course Caretaker
---        |-------------------------------|--------|----------------
CR-4403    | Ceramic Equipment Design      | 3      | Prof. S. Dasgupta

Course Description:
Design of tunnel kiln for refractory bricks; Design of roller hearth kin for tile industry; Design of a glass tank furnace Design of an autoclave for production of alumina from Bayer’s Process, Design of a tray drier for drying alumina cakes; Design of two strand tundish, Design of a ball
mill, Design of electrically heated laboratory furnace, design of spray drier/spray pyrolyzer heating chamber, Design of L-D converter lining, Design of Ladle lining

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<tr>
<td>CR-4402</td>
<td>Waste management of ceramic industries</td>
<td>3</td>
<td>Prof. S. K. Pal</td>
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</tbody>
</table>

**Course Description:**
Pollution and waste generation in ceramic and related industries. Kiln and stack emissions, pollution from service units like air compressor, laboratories, gas producers, storage facilities, waste water treatment plant etc; Environmental and health impacts of pollutants and solid wastes. Indian environmental laws and WHO's norms. Pollution reduction measures in ceramic industries: air, sound, solid waste, water. Nature and type of industrial waste useful for ceramic industries. Use of industrial wastes in ceramic industries Utilization of fly ash, rice husk, BF slag in the production of traditional, advanced ceramics. Utilization of red mud and recovery of metals from red mud. Application of zeolite in environment (catalytic effect, water purification). Clay as an absorbent of toxic pollutant; Recycling of industrial waste. Fluorine contamination in alumina Industry disposal and recovery of refractory materials. Ceramics for water and air purification. Glass & glass ceramics in nuclear waste management

**Essential Reading:**
2. C. C. Herman (Editor), S. Marra (Editor), D. R. Spearing (Editor), L. Vance (Editor) and J. D. Vienna (Editor), *Environmental Issues and Waste Management Technologies XI, Ceramic Transactions, Volume 176*. John Wiley & Sons, edition, 2005.

**Supplementary Reading:**

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<tr>
<td>CR-4102</td>
<td>Tribology of Materials</td>
<td>3</td>
<td>Prof. D. Sarkar</td>
</tr>
</tbody>
</table>

**Course description**
Introduction: Different types of materials and applications, surface characterization (Physico – chemical characteristics of surface layers) Surface visualization, Geometry of non – conforming surfaces (analysis and measurement of surface roughness), Surface and subsurface stress distributions and Hertzian contact; Contact between solid surfaces; Adhesion Friction; Testing, Frictional behavior (Solid – solid contact, liquid mediated contact), Friction mechanism of metals, ceramics and polymers, solid lubricants. Thermal properties of sliding surfaces; Classification of wear and wear testing, role of humidity; the various modes of wear: adhesive, delamination, fretting, abrasive, erosive, corrosive, oxidizing (mild and severe), melt and the wear-mechanism maps, types of particle present in wear debris; Surface Engineering Methods to reduce wear, Electrolytic, Spraying, Hard-facing, Chemical Vapour Deposition (CVD), Plasma Vapour Deposition (PVD), Mechanical methods, Surface melting and Thermo chemical treatments; Lubrication: Solid lubricants, Liquid lubricants, Fluid film lubrication, Introduction to Elasto-Dynamic (ED) and Elasto- Hydro Dynamic (EHD) Lubrication, Mixed and Boundary lubrication, micro and nano tribology, solution of tribological problems, recent developments in this area.

**Essential Reading:**
## Supplementary Reading

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<tr>
<td>CR-4204</td>
<td>Ceramic coating</td>
<td>3</td>
<td>Prof. S. Dasgupta</td>
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</tbody>
</table>

### Course Content

### Essential Reading
1. K. Seshan, Hand Book of Thin Film Deposition Technique, William Andrew INC, 2002

## Supplementary Reading

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<tr>
<td>CR-4306</td>
<td>Ceramics in energy sector</td>
<td>3</td>
<td>Prof. R. Mazumder</td>
</tr>
</tbody>
</table>

### Course Description:

### Optical Ceramics

**Course Description:**
Fundamental Optical Properties of Materials; Materials and fabrication techniques; Different Characterization techniques; Processing of transparent and optical ceramics; Refractive index and extinction coefficient; Negative Index of Refraction: Optics and Metamaterials; Electro-optic effects.; Optical Properties of Disordered Condensed Matter; Excitons; Photoluminescence; Fluorescence; Nonlinear Optical Properties; Solid State Lasers; Optical Glass Waveguides; Semiconductors in Optical application; Photovoltaics; Photonic MEMS Devices: Device ; Processing and Application

**Essential Reading**
1. Optical Properties of Condensed Matter and Applications Optical Properties; Jai Singh; John Wiley & Sons Ltd.; 2006
2. Transparent Ceramics; Ling Bing Kong, Y. Z. Huang; Springer International Publishing; 2015

**Supplementary Reading**
1. GLASSES FOR PHOTONICS; MASAYUKI YAMANE and YOSHIYUKI ASAHARA; Cambridge University Press; 2000
2. Principles and Applications of Nonlinear Optical Materials; R.W. Munn; Springer; 1993

### Industrial Furnace Design

**Course Description**
Basics of designing and drafting tools, Study and drawing of different refractory bricks of standard shape, Study and drawing of non-standard shapes of refractory bricks, Drawing of brick wall and brick joints, Drawing of different parts of rotary kiln, Drawing of converter, Drawing of ladle, Drawing of Blast Furnace Trough Lining, Drawing of slide plates refractories, Drawing of sub entry nozzle, Drawing of monoblock stopper, Chimney calculation and drawing of chimney.

**Essential Reading**
1. Industrial and Process Furnaces: Principles, Design and Operation; Barrie Jenkins; Butterworth-Heinemann; 2013
2. Design & Construction of Electric Furnaces; Wilhelm Borchers; Wexford College Press; 2005

**Supplementary Reading**
1. Industrial Furnaces; W. Trinks ; John Wiley & Sons; 2004

### Introduction to Ceramics

**Course Description**
Introduction, definition and scope of ceramics. Historical perspective, classification, Ceramics and Civilization ; Traditional ceramics: An overview, history, compositions, manufacturing and application of refractories, whitewares and heavy clay wares, glass, cement, ceramic coatings The development of modern ceramic technology, processing of ceramic powders, shape forming operations: pressing, slip casting, isostatic pressing, injection moulding, sheet forming, MLC technology. Firing of ceramics: kiln design and conveyor technology, sintering and densification, hot pressing and hot isostatic pressing. Sol –gel processing and monolithic ceramics. Basic glass processing, container glass, fibre glass, speciality glass products, glass-ceramics, glass microspheres, laminated glass, photochrome and photo sensitive glass Modern / high tech ceramics, high tech functions and functional ceramics, structural ceramics, electrical and electronic ceramics, chemical and nuclear ceramics, bio-ceramics, ceramic membranes, artificial gems and ceramics, aerospace and other strategic
applications of ceramics, advanced ceramic processing techniques. Energy and pollution controls.

**Essential Reading:**

**Supplementary Reading:**

### Sub. Code. | Course Name          | Credit | Course Caretaker
---             | ---                | ---    | ---
CR-0002        | Properties of Ceramics | 3     | Prof. S. K. Pratihar

**Course Description:**
Mechanical Properties: Concept of strength and its relation with fundamental parameters, plastic deformation, viscous flow, creep, Fracture of materials; Thermal Properties: Thermal expansion, thermal shock, annealing and chemical strengthening, specific heat and heat capacity, thermal conduction process; Electrical Properties: Electrical, electronic and ionic conduction phenomena in crystals. Fast ionic conductors, glasses and non-stoichiometric compounds. PTCR, NTCR, Varistors, thermisters etc; Dielectric Properties: Dielectric loss of crystals and glasses, dielectric strength, piezoelectric and ferroelectric ceramics; Magnetic Properties: Concept of magnetic phenomena in solids. Structure and magnetic properties of spinel ferrites, rare-earth garnets, ortho-ferrites and hexagonal ferrites with special reference to their microstructure; Optical Properties: Refractive index and dispersion, reflectance, opacity and translucency, absorption and colour from modern concepts in crystalline and vitreous ceramic systems.

**Essential Reading:**

**Supplementary Reading:**

### Sub. Code. | Course Name          | Credit | Course Caretaker
---             | ---                | ---    | ---
CR-0003        | Ceramic fabrication | 3     | Prof. S. Bhattacharyya

**Course Description:**

**Essential Reading:**
Supplementary Reading:

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<tbody>
<tr>
<td>CR-0004</td>
<td>Industrial Ceramics</td>
<td>3</td>
<td>Prof. R. Sarkar/Prof. S. K. Pal</td>
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Course description

Essential Reading:

Supplementary Reading:

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<tr>
<td>CR-0005</td>
<td>Ceramic testing and characterization</td>
<td>3</td>
<td>Prof. B. B. Nayak/ Prof. (Mrs) S. Bhattacharyya</td>
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</table>

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>CR-0006</td>
<td>Advanced Ceramics</td>
<td>3</td>
<td>Prof. S. Bhattacharyya/ Prof. R. Mazumder</td>
</tr>
</tbody>
</table>

**Course description**
Introduction and classification of Structural Ceramics, Brief review of Griffith theory of fracture, toughness, statistical nature of strength Alumina and alumina ceramics Crystal structure, phases, types of alumina, properties and its relation to microstructure, importance and application. Zirconia Ceramics Crystal structure and polymorphic modifications, Transformation Toughening; different system in zirconia, application. Composites: strengthening and toughening mechanisms, composite fabrication. Composites of some oxides and nonoxides. Classification of non-oxide ceramics, siliconcarbide, siliconnitride Sialon, Tungsten Carbide, Boron Carbide, Boron Nitrde, Carbon and Graphite, phase diagrams, processing, sintering and properties. Abrasives; natural and synthetic; properties, applications and performances; Semiconductor, electronic, ionic conductors and fast ion conductors; defects influride type andperovskite oxides; conduction process and transference number; electronic conduction in oxides; semiconductor - metal transition; Ionic conduction in oxides; fast –ion conductors; resistors and varistors, ceramic capacitors, piezoelectric and electro-optic ceramics, Super conductivity: basic principles; materials; synthesis and applications; Magnetic Ceramics: Introduction; types of magnetism: magnetic anisotropy; magnetostriiction; domains and magnetization processes; magnetic Materials: soft and hard; synthesis; characterization and applications, ferroelectricity in capacitor technology, recent developments in this area.

**Essential Reading:**

**Supplementary Reading:**

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<tbody>
<tr>
<td>CR-0007</td>
<td>Industrial ceramics processing lab</td>
<td>1</td>
<td>Prof. A. Paul/ Prof. P. Saha</td>
</tr>
</tbody>
</table>
Course description
6. Effect of relative humidity on the green density of dry pressed bodies. Study of compaction behaviour of ceramic powder. Effect of powder and pressing properties on the generation of various defects in dry pressed articles. Effect of different drying conditions on the properties of dried articles prepared by slip casting.

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<tr>
<td>CR-0008</td>
<td>Ceramic characterization lab</td>
<td>1</td>
<td>Prof. B. B. Nayak</td>
</tr>
</tbody>
</table>

Course description
Study of thermal decomposition behaviour of dolomite / limestone/ magnesite; Study of phase transition in quartz by DTA; Weight loss behaviour of dolomite, magnesite and limestone by TGA; Study of thermal expansion behaviour and determination of thermal expansion coefficient of ceramic product; Determination of thermal hysteresis of zirconia by dilatometric method; Study and operation of x-ray diffractometer; Indexing of cubic crystal system and determination of its lattice parameter; Determination of lattice parameter of tetragonal crystals; Determination of crystallite size from x-ray line broadening; Study of data acquisition and processing for obtaining an x-ray profile; Phase identification using software; Determination of a calibration curve for quantitative estimation of two-phases in a mixture.

DEPARTMENT OF COMPUTER SCIENCE ENGINEERING

Subject Code: CS2001

Subject Title: Digital System Design [Core 1]

Pre-requisites: None

Course Objective:

1. Able to perform the conversion among different number systems; Familiar with baisc logic gates
2. Understand Boolean algebra and basic properties of Boolean algebra; able to simplify simple Boolean functions by using the basic Boolean properties.
3. Able to design combinational logics using basic gates, optimize simple logic using Karnaugh maps.
4. Familiar with basic sequential logic components: SR Latch, D Flip-Flop and their usage and able to analyze sequential logic circuits
5. Familiar with basic combinational and sequential components used in the typical datapath designs: Register, Adders, Shifters, Comparators; Counters, Multiplier, Arithmetic-Logic Units (ALUs), RAM.

Course Outcomes:

1. An ability to define different number systems, binary addition and subtraction, 2’s complement representation and operations with this representation
2. An ability to understand the different switching algebra theorems and apply them for logic functions.
3. An ability to define the Karnaugh map for a few variables and perform an algorithmic reduction of logic functions.
4. An ability to define combinational circuits, such as, encoders/decoders, (de)multiplexers, comparators, arithmetic-logic units; and to be able to build simple applications.
5. An ability to understand sequential circuits, like counters and shift registers, and to perform simple projects with them.

Course Contents:

Unit I

Binary Systems: Introduction to Number Systems and conversions. Arithmetic with number systems, Signed and unsigned number systems and their arithmetic. Binary Codes

Unit II

Boolean Algebra & Logic Gates: Boolean Functions and their Complements, Standard forms & Canonical Forms, Digital logic gates, Gate level Minimization, Karnaugh maps, Digital Circuits using Basic and Universal Gates

Unit III

Combinational Logic Circuits: Analysis and Design of combinational circuit, Code Converters, Adders and its types, Subtractors, Multiplier, Magnitude Comparator, Decoders and Encoders, Multiplexers and Demultiplexers.

Unit IV

Sequential Logic Circuits: Latches (SR Latch, D Latch), Flip Flops (D Flip Flop, JK Flip Flop, T Flip Flop), Characteristic Tables, Characteristic Equations. Design and Analysis of Clocked Sequential Circuits (State Equations, State Tables, State Diagrams), Designing Asynchronous and Synchronous Counters

Unit V

Registers: Simple registers, Registers with parallel Load, Shift Registers, Serial to parallel Convertors. Universal Shift Register

Unit VI

Introduction to Memories and Programmable Logic: Random Access memory, types of ROM, Memory decoding, address and data bus, Sequential Memory, Cache Memory, Programmable Logic Arrays, memory Hierarchy in terms of capacity and access time., PLA, PAL

Essential Reading:


Supplementary Reading:

Subject Code: CS2002

Subject Title: Discrete Structures

Prerequisites: Nil.

Course Objectives:
1. To discuss the concepts associated with set theory, propositions, predicate calculus, relations and functions, and their applications.
2. To discuss the basic concepts of permutations, combinations, discrete probability and conditional probability.
3. To discuss the concepts and terminologies associated with graph theory, graph coloring problem various graph traversal techniques, trees and cut-sets.
4. To carry out the analysis of algorithms such as finding the complexity of various algorithms.
5. To describe the concepts of discrete numeric functions and various types of recurrence relations and the methods to find out their solutions.
6. To present the concepts of groups and rings. Also, we aim at describing the applications of groups to error detection and correction.
7. To present the principles and properties of boolean algebra and the application of boolean algebra to switching circuits.

Course Outcomes:

After reading this subject, students will be able to:
1. Understand set theory, propositions, predicate calculus, permutations and combinations, relations and functions and their applications in Problem solving.
2. Understand graph-theory, trees and cut-sets.
3. Understand formal languages and finite machines.
4. Analyze different algorithms and find the space & time complexities of algorithms.

5. Understand discrete numeric functions and generating functions and their applications.

6. Understand concepts of groups, rings and field and their applications in error detection & correction.

7. Understand Boolean algebra & their applications in Switching network.

**Course Contents:**


**Essential Readings:**


**Supplementary Readings:**


4. N. Deo, Graph Theory with applications to Engineering & Computer Science, Prentice Hall of India, 2006.

Subject Code: CS2003
Subject Title: Data Structures & Algorithms [Core 3]
Pre-requisites: Nil

Course Objectives:

1. To develop students' knowledge in data structures and the associated algorithms.
2. To introduce the concepts and techniques of structuring and operating on abstract Data Types in problem solving.
3. To discuss common sorting, searching algorithms. Also the complexity and comparisons among these various techniques.

Course Outcomes:

1. Describe the usage of various data structures
2. Explain the operations for maintaining common data structures. Recognize the associated algorithms' operations and complexity
3. Recognize the associated algorithms' operations and complexity.
4. Design and apply appropriate data structures for solving computing problems.
5. Develop computer programs to implement different data structures and related algorithms. Possess the ability to design simple algorithms for solving computing problems.
Course Contents:


Essential Readings:

1. An introduction to Data Structures with Applications By Tremblay & Sorension [MGH]

Supplementary Readings:


Subject Code: CS2004
Subject Title: Formal Languages and Automata Theory [Core 4]
Prerequisites: Set Theory, Discrete Structures
Course Objectives:

1. To focus on the study of abstract models of computation. These abstract models allow the students to assess via formal reasoning what could be achieved through computing when they are using it to solve problems in science and engineering.
2. The course exposes students to the computability theory, as well as to the complexity theory. The goal is to allow them to answer fundamental questions about problems, such as whether they can or not be computed, and if they can, how efficiently.
3. The course introduces basic computation models and their properties, and the necessary mathematical techniques to prove more advanced attributes of these models.

Course Outcomes:

The goal of this course is to provide students with an understanding of basic concepts in the theory of computation. At the end of this course students will be able to:

1. Construct finite state machines and the equivalent regular expressions. Prove the equivalence of languages described by finite state machines and regular expressions.
2. Construct pushdown automata and the equivalent context free grammars. Prove the equivalence of languages described by pushdown automata and context free grammars.
3. Construct Turing machines and Post machines. Prove the equivalence of languages described by Turing machines and Post machines.

Course Contents:

Introduction to Automaton. Finite Automata and Regular Expressions: Deterministic and nondeterministic finite automata, regular expressions, Two way finite automata, finite automata with output: Mealy and Moore machines; Properties of Regular Sets: Pumping lemma, closure properties, decision algorithm, MyHill- Nerode theorem and minimization of finite automata; Context-Free Grammars (CFG): CFGs, derivation trees, simplification, Chomsky normal forms, Greibach normal forms; Pushdown Automata(PDA): Definitions, relationship between PDA and context free languages; Properties of Context-Free Languages: Pumping lemma, closure properties, decision algorithm; Turing Machines: The Turing machine model, computable languages and functions, techniques for Turing machine construction, modification of Turing machines, church’s hypothesis, Turing machines as enumerators; Un-decidability: properties of recursive and recursively enumerable languages, universal Turing machines, rice’s theorem, post correspondence problem; Chomsky Hierarchy: regular grammars, unrestricted grammars, context sensitive languages, relations between classes of languages. P, NP, NP-complete, and NP Hard class of problems.

Essential Reading:


Supplementary Reading:


Subject Code: CS2005

Subject Title: Computer Organization & Architecture

Prerequisites: EC 202 (Digital Electronics)

Course Objectives

1. Understand the computer system architecture and instruction execution through instruction cycles
2. Understand the system interconnection and the different I/O techniques.
3. Explain the basic concept of interrupts and their usage to implement I/O control and data transfers.
4. Explain the functioning of arithmetic and logic unit, central processing unit and memory
5. Identify the different architectural design issues that can affect the performance of a computer such as, RISC architecture, instruction set design, and addressing modes

Course Outcomes:

1. Describe computer architecture and organization, computer arithmetic, Memory and CPU structure and function.
2. Describe I/O organization and interconnection structures of computer.
3. Identify high performance architecture design.

Course Contents
Overview of Computer Architecture and Organization: Contrast between computer architecture and organization; Fundamentals of computer architecture: Organization of von Neumann machine; Instruction format; execution cycle; Instruction types and addressing modes; Computer Arithmetic: representation of integers and real numbers; algorithm for carrying out common integer and floating-point operation; Memory system organization and architecture: Memory system hierarchy; main memory organization; cache memory; virtual memory; Interfacing and Communication: I/O fundamentals; I/O techniques; Interrupt; memory system design and Interfacing; Buses; Device subsystem: External storage system; RAID architecture; Control Unit Design: Instruction sequencing, Instruction interpretation, control memory, Hardwired Control, Micro programmed Control, Micro programmed Computers. I/O organization: Bus control, Serial I/O (study of Asynchronous and synchronous modes, USART & VART), Parallel Data transfer: (Program controlled: Asynchronous, synchronous & Interrupt driven modes, DMA mode, interrupt controller and DMA controller). Organization of CPU: Single vs multiple data path; ISA; Control unit; Instruction pipelining; Trends in computer architecture: CISC, RISC, VLIW, Introduction to ILP; Pipeline Hazards: Structural, data and control; Reducing the effects of hazards.

Essential Reading:

Supplementary Reading:

Subject Code:CS2006

Subject Title: Design and Analysis of Algorithms [Core 6]

Prerequisites: Data Structure

Course Objectives: The student should be made to:
1. Learn the algorithm analysis techniques.
2. Become familiar with the different algorithm design techniques.
3. Understand the limitations of Algorithm power.

Course Outcomes:
1. Design algorithms for various computing problems and analyze the time and space complexity of algorithms.
2. Choose appropriate data structures and algorithms, understand the ADT/libraries, and use it to design algorithms for a specific problem.
3. Understand the necessary mathematical abstraction to solve problems and come up with analysis of efficiency and proofs of correctness. Comprehend and select algorithm design approaches in a problem specific manner and also modify existing algorithms to improve efficiency.
Course Contents:


Essential Reading:


Supplementary Reading:


Course Code: CS2007

Course Title: Database Engineering [Core 7]

Prerequisites: CS2003 (Data Structures and Algorithms)

Course Objectives:

1. To provide students with basic concepts in databases both in terms of usage and implementation
2. To make the students understand all requirement and operations that the analyst needed to analyze, design, and implement the systems
3. To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementation

Course Outcomes:

1. Aware of various database systems and its design issues
2. Design and implement a database for any specified domain according to well-known design principles that balance data retrieval performance with data consistency guarantees
3. Formulate data retrieval queries in SQL and the abstract query languages
Course Content:

*Introduction to Database systems*: Data Independence, Data Models, levels of abstraction, structure of DBMS, Relational Model, Relational Languages, Query Languages: Relational Algebra, Relational Calculus, SQL, QUEL, QBE, Integrity constraints, Aggregate operators, Embedded and Dynamic SQL.

Database design: E-R Model, Functional dependencies, decomposition, normalization, multivalued dependencies.

*File Organization*: Storage, Buffer management, Disk Management, File organization techniques, Indexing.

*Query optimization*: Query processing on various operations, Translating SQL queries, estimating the cost.

Concurrence control and recovery: transaction, schedules, Lock based concurrency, Lock management, Concurrency control without locking, Crash recovery - log, check pointing, media recoveries.

*Advanced topics*: Database Security, Distributed databases design, Object Oriented database design & its implementation, Introduction to recent advances in database technology.

**Essential Reading:**


**Supplementary Reading:**


**Subject Code**: CS3008

**Subject Title**: Data Communication [Core 8]

**Prerequisites:**

**Course Objectives:**

1. To learn the principles of digital communication systems for industry and research
2. To design and implement protocols for data communication systems

**Course Outcomes:**

1. Ability to design and develop data communication protocols and interface standards for industry as well as research organizations
2. Ability to design efficient and effective data communication system

**Course Contents:**

*Data transmission fundamentals*: historical overview; time/frequency representation of data signals; elements of a communications link; definition of key terms; factors affecting system design, Standards & Protocols, OSI reference model, TCP/IP protocol suite

*Binary and multi-level signaling*: information transfer rate; calculation of channel capacity; bandwidth efficiency, Baseband data transmission: the problem of inter symbol interference;
Achieving a Nyquist channel response; recovery of symbols from noise; bit error rate performance for baseband data systems, Error detection and correction

**Band pass digital modulation:** binary modulation schemes (e.g. ASK, FSK, PSK); multi-level digital modulation (e.g. M-ary ASK, M-ary FSK, M-ary PSK, QAM), MODEM

Source coding; channel coding; block coding; convolutional coding; combined coding and modulation, Multi-user digital modulation techniques such as frequency division multiple access (FDMA); time division multiple access (TDMA); code division multiple access (CDMA); combined multiple access systems;

**Essential Reading:**


**Supplementary Reading:**


**Subject Code:** CS3009

**Subject Title:** Object-Oriented System Design [Core 9]

**Prerequisites:**
- Object-oriented programming languages such as C++/Java
- System Analysis and Design
- Database

**Course Objective:**
- To learn the concept of object-oriented software development process
- To get acquainted with UML diagrams
- To develop real-life object-oriented software

**Course Outcomes:** After reading this subject, student will be able to
- Understand object-oriented software development methodology.
- Apply object-oriented methodology to develop real-life projects
encapsulation and information hiding, class hierarchy, polymorphism, object relationships and associations, aggregations and object containment, case study, object identity, persistence.

**Essential Reading:**
1. Blaha and Rumbaugh, Object-oriented Modeling and design with UML, 2nd Ed, 2005

**Supplementary Reading:**

**Subject Code:** CS3010

**Subject Title:** Microprocessors and Microcontrollers [Core 10]

**Prerequisites:** Digital Logic Design (CS343)

**Course Objectives:**
This course provides an in-depth understanding of the operations of microprocessors and microcontrollers, assembly language programming, and peripheral interfacing.

**Course Outcomes:**
At the end of the course the students will ---
1. learn the principles and components of microprocessor.
2. develop programs in assembly language.
3. understand the memory organization, memory interfacing, timing diagrams, etc.
4. acquire skills to interface and program peripherals.
5. gain knowledge of microcontrollers and their applications.

**Course Contents:**
Overview of 8085 microprocessors; signals, pins, and assembly language programming.
Overview of 8086 microprocessors; signals, pins, and assembly language programming.
Interfacing with RAMs, ROMs along with the explanation of timing diagrams. Interfacing with peripheral ICs like 8255, 8254, 8279, 8259, 8259, etc. Interfacing with keyboards, LEDs, LCDs, ADCs, and DACs etc. Architecture of 8087, interfacing with 8086. Data types, instructions and programming. Overview of 8051, 8096 microcontrollers; assembly language programming. Interfacing with microcontroller. Introduction high end processors.

**Essential Reading:**

**Supplementary Reading:**
Subject Code: CS3011

Subject Title: Compiler Design [Core 11]

Pre-requisites: CS 331 Theory of Computation, CS 213 Principles of Programming Languages

Course Objective:

This course aims to introduce the fundamental principles and techniques of compiler construction. Emphasis will be on the practical aspects of designing and creating a custom-purpose compiler using appropriate tools.

Course Outcomes:

Upon successful completion of this course, students should be able to:

1. Explain the principles behind compiler construction.
2. Apply the techniques learned in class to compiler construction.
3. Design, create and implement basic components of a custom purpose compiler for a simple language.

Course Contents:

Introduction and overview of the compilation process, Model of a compiler, translators, interpreters, assemblers. Compilation of simple expressions and statements, Organization of a compiler, Compiler design tools, Computer architecture vs. compiler design; Lexical analyser (scanner); DFA; NFA; Context-Free Grammar. Syntax analysis, parsing: Top-Down and Bottom Up parsing, general parsing strategies. Brute-force approach, recursive descent parser and algorithms, simple LL(1) grammar, LL(1) with null and without null rules grammars, Bottom-up parsing- Handle of a right sentential form, Shift-reduce parsers, operator precedence parsing, LR, SLR, canonical LR and LALR grammar and parsers; Symbol Table contents, organization and Management. Syntax-directed translation schemes, intermediates code generation, translation schemes for programming language constructs. Code Optimization, Code Generation, Error Handling.

Essential Reading:


Supplementary Reading:


Subject Code: CS3012

Subject Title: Operating Systems [Core 12]

Prerequisites:

Course Objectives:

1. General understanding of structure of modern computers
2. To understand the purpose, structure and functions of operating systems
3. To illustrate key OS aspects by example
4. To study and apply concepts relating to operating systems, such as concurrency, deadlocks, memory management, processor and disk scheduling, parallel processing, and file system organization

**Course Outcomes:**

Up on successful completion of this course a students should be able to:

1. Explain the basic structure and functions of operating system
2. Point the problems related to process management and synchronization and apply learned methods to solve basic problems
3. Explain the cause and effect related to deadlocks and to analyse them related to common circumstances in operating systems
4. Explain the basics of memory management, the use of virtual memory in modern operating systems and the structure of the most common file-systems

**Course contents:**

*Introduction:* review of computer organization, operating system structures, system calls, system programs, virtual machine; *Process:* Process concept, Process scheduling, Operations on processes, Cooperating processes, Inter-Process-Communication (IPC), Communication in client-server systems; Case study: IPC in Linux; Threads, Multi-threading models, Thread issues, Case study: Pthreads library.

*CPU Scheduling:* Scheduling criteria, Scheduling algorithms, Multiple processor scheduling, Real time scheduling, Algorithm evaluation, Case Study: Process Scheduling in Linux; Process synchronization: The critical section problem, Synchronization hardware, Semaphores, Classical problems of synchronization, Methods for handling deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection, Recovery from Deadlock;

*Memory Management:* Background, Swapping, Contiguous memory allocation, Paging, Segmentation, Segmentation with paging, Virtual memory: Background, Demand Paging, Process Creation, Page replacement, Allocation of frames, Thrashing, Case Study: Memory management in Linux;


**Essential Reading:**


**Supplementary Reading:**

Subject Code: CS3013

Subject Title: Computer Networks [Core 13]

Prerequisites: CS 326

Course Objectives

1. To gain the knowledge of computer networks.
2. To understand the network models and their architecture.
3. To understand the protocols for each layers in the OSI and TCP/IP model.
4. To understand the different topologies.
5. To learn about the MAC layer issues and routing protocols.

Course Outcomes:

Upon completion of this module, students will be able to:

1. Analyze the requirements for a given organizational structure and select the most appropriate networking architecture and technologies;
2. Specify and identify deficiencies in existing protocols, and then go onto formulate new and better protocols;
3. Analyze, specify and design the topological and routing strategies for an IP based networking infrastructure
4. Have a working knowledge of datagram and internet socket programming?
5. To master the terminology and concepts of the OSI reference model and the TCP-IP Reference model.
6. To master the concepts of protocols, network interfaces, and Design / performance issues in local area networks and wide area networks.
7. To be familiar with contemporary issues in networking technologies.
8. To be familiar with network tools and network programming.

Course Contents

Network fundamentals: protocols and standards; reference models; the significance of layered network architectures; connections and connectionless protocols, Physical links and interfaces: modems and modem standards; LAN characteristics and concepts; interconnection of LANs; WAN characteristics and concepts, Link layer aspects, synchronous and asynchronous transmission; Framing, Error detection and correction, Sliding window protocols; MAC Layer; network layer aspects, addressing, connection vs connectionless, Routing Algorithms, internetworking; transport layer aspects, reliable transport connections, Internet Protocol (IP); naming and addressing; routing; the Transmission Control Protocol (TCP); application and management protocols. Exploring Internet services: the dial-in end-user; the direct connection user; the Internet Service Provider; the global Internet. Emerging technologies over the Internet, such as IPv6 and ATM for a multimedia network; Internet Telephone;

Essential Reading:


Supplementary Reading:

Subject Code: CS3014

Subject Title: Software Engineering [Core 14]

Course Objectives:

- To discuss the software engineering discipline - its evolution, impact and emergence of software engineering and explain the development and use of different software life cycle models for real life industrial applications.
- To discuss different aspects of software project management, risk management and configuration management and explain various requirement elicitation, analysis and specification techniques.
- To discuss various software design methodologies, the impact of cohesion and coupling measures on the goodness of the software design.
- To discuss the importance of practicing different coding standards, guidelines and different testing strategies along with software reliability metrics and software quality management techniques & standards.
- To present the concepts of computer aided software engineering (CASE) and discuss the concepts of software maintenance and reuse.

Course Outcomes:

After reading this subject, students will be able to:

1. Choose a proper life cycle model for different real life industrial applications, design software using function-oriented approach (DFDs) and object-oriented approach (UML diagrams).
2. Understand the concepts of computer aided software engineering (CASE) and use different CASE tools in the development, maintenance and reuse of software systems.
3. Know the emerging concepts like cloud computing, middlewares, SOA etc., their functioning and their applications in real life problems.

Details of Course Contents:


Essential Readings:


Supplementary Readings:

Subject Code: CS3015

Subject Title: Distributed Systems [Core 15]

Prerequisites: Operating System, Computer Organization & Architectures

Course Objectives:

Course Outcomes:

- understand basic problems in distributed computing, especially in relation to concurrency, parallelism, synchronization, deadlocks, safety and liveness properties;
- understand differences between various distributed computing models and widely used distributed computing schemes;
- Understanding communication mechanism among the distributed entities
- Authentication and self-stabilization issues in distributed system

Syllabus:

A model of distributed computations: A distributed program, A model of distributed executions, Models of communication networks, Global state of a distributed system, Cuts of a distributed computation, Past and future cones of an event, Models of process communications.

Logical time: Introduction, A framework for a system of logical clocks, Scalar time, Vector time, Efficient implementations of vector clocks, Jard–Jourdan’s adaptive technique, Matrix time, Virtual time, Physical clock synchronization: NTP.

Global state and snapshot recording algorithms: System model and definitions, Snapshot algorithms for FIFO channels, Variations of the Chandy–Lamport algorithm, Snapshot algorithms for non-FIFO channels, Snapshots in a causal delivery system, Monitoring global state, Necessary and sufficient conditions for consistent global, snapshots, consistent global snapshots in a distributed computation.

Message ordering and group communication: Message ordering paradigms, Asynchronous execution with synchronous communication, Synchronous program order on an asynchronous system, Group communication, Causal order (CO), Total order, A nomenclature for multicast, Propagation trees for multicast, Classification of application-level multicast algorithms, Semantics of fault-tolerant group communication, Distributed multicast algorithms at the network layer.

Termination detection: System model of a distributed computation, Termination detection using distributed snapshots, Termination detection by weight throwing, A spanning-tree-based termination detection algorithm, Message-optimal termination detection, Termination detection in a very general distributed computing model, Termination detection in the atomic computation model, Termination detection in a faulty distributed system.


Authentication in distributed systems: Protocols based on symmetric cryptosystems, Protocols based on asymmetric cryptosystems, Password-based authentication, and Authentication protocol failures.


Essential Reading:

Supplementary Reading:
1. Hagit Attiya, Jennifer Welch, Distributed Computing: Fundamentals, Simulations, and Advanced Topics, Wiley
2. Andrew S. Tanenbaum, Maarten van Steen, Distributed Systems: Principles and Paradigms, Prentice Hall of India

Subject Code: CS3101

Subject Title: Principles of Programming Languages

Prerequisites: Computing Laboratory - 1 (CS-171), Computing Laboratory - 2 (CS - 172)

Course Objectives:

1. to provide an introduction to formalisms for specifying syntax and semantics of programming languages
2. to learn the essence of program execution by evaluators: Compilers, Interpreters
3. to understand the major issues of design, analysis, and implementation of programming languages
4. to explore various important programming methodologies, such as functional programming, logic programming, programming with abstract data types, and object-oriented programming

Course Outcomes:

Up on successful completion of this course a student will be able to:

1. choose appropriate programming languages for certain classes of programming problems
2. make good use of compilers, interpreters, debuggers, and related tools
3. demonstrate correspondences between grammars, languages and automata
4. use context-free grammars to specify programming language syntax
5. simulate useful features in languages that lack them

Course Content


Other Paradigms: Logic Programming, an Introduction to Concurrent Programming.

Essential Reading:

1. R. Sethi, Programming Languages – Concepts & Constructs, 2nd Ed, Pearson Education.

Supplementary Reading:


Subject Code: CS3102

Subject Title: Systems Analysis and Design

Course Objectives

1. To introduce variety of new software used by analysts, designers to manage projects, analyze and document systems, design new systems and implement their plans.
2. Good understanding of project management functions and estimation techniques.
3. Describe various logic modeling techniques and conceptual modeling techniques for system's analysis.
4. Describe different methodologies and state-of-the-art development in SA&D techniques and methods

Course Outcomes

1. Understand the principles and tools of systems analysis and design
2. Understand the application of computing in different context
3. Solve a wide range of problems related to the analysis, design and construction of information systems
4. Comprehend the importance of collaboration and communication during SA&D

Course Contents

systems, Management information systems, Decision support systems, Expert systems, and Computer based information systems (CBIS)

System Analysis Concepts: System development life cycle, system analysis, system design, Roll of System Analyst, Classical and structured approaches of system analysis and design, Depicting system graphically, determining feasibility, activity planning and control, Describing process specifications and structured decisions, designing of outputs, inputs, files and database. Coding, testing, installation methods.

Structured Analysis tools: DFD, Data dictionary, Decision tree etc., Systems Design, input/output design, Software Design and Documentation tools: HIPO and Warnier / Orr Diagrams

Essential Readings


Supplementary Reading


Subject Code:CS3103

Subject Title: Real Time Systems

Prerequisites: Operating systems and Databases.

Course Objectives:

1. To introduce the characteristics of Real-Time systems and their different types.
2. To discuss and analyze different task scheduling algorithms in uniprocessor and multi-processor environments.
3. To explain the characteristics and constraints of some commercial real-time operating systems.
4. To discuss the features and algorithms for real-time communications to take place in different network structures.
5. To explain the characteristics of real-time databases and their applications in real world.

Course Outcomes:

1. Understand and develop real-time applications.
2. Develop efficient algorithms for real-time task scheduling in uniprocessor and multi-processor environments.
3. Get an exposure to the different types of commercial real-time operating systems.
4. Identify the limitations of a non-real-time operating system in running a real-time application.
5. Identify and address the important issues in real-time communications and will be able to use real-time databases.
Course Contents:


Scheduling Real-Time tasks in multiprocessor and distributed systems, Fault tolerant scheduling of tasks, clocks in distributed Real-Time systems.

Commercial Real-Time Operating Systems, timers, UNIX and Windows as RT OS, POSIX, PSOS, VRTX, QNX, RT Linux, Lynx, other RT OS, benchmarking RT OS, Real-Time OS: OS services, I/O subsystem, Network OS.

RT communications: QoS framework, models, Real-Time Communication in a LAN, IEEE 802.4, RETHER, Communication over Packet Switched Networks, Routing algorithms, RSVP, rate control.

RT databases, Applications, characteristics of temporal data, Concurrency control, Commercial RT databases, Special topics in Real-Time systems.

Essential Readings:


Supplementary Readings:


Subject Code: CS3304

Subject Title: Computer Graphics

Prerequisites:

Programming Language (C or C++), Data Structures and Algorithms (CS171, CS172, and CS102)

Acquaintance with Linear Algebra, Vector Geometry, and Coordinate Geometry

Course Objectives:

This course provides a comprehensive introduction to computer graphics theory leading to the ability to understand contemporary terminology, progress, issues, and trends.

Course Outcomes:

At the end of the course the students will ---

1. learn the fundamental principles and technologies of computer graphics.
2. have the critical understanding of the theory of 2D and 3D transformations, projection, viewing, drawings of graphics primitives, curves, surfaces, etc.
3. develop interactive programs that use effectively the graphics functionalities available in contemporary computers.
4. acquire the necessary skills to design and implement practical graphic solutions to challenging problems in different application domains.

Course Contents:

Introduction to Computer Graphics; Graphics primitives; point, line, circle, ellipse drawing algorithms; Introduction to OpenGL; Transformations; Homogeneous Coordinates; Composite
Transformations; Camera Models; Viewing; Projections; Clipping; Visible surface detection; Lighting and Reflections; Shading; Interpolation; Curves and Surfaces; Ray Tracing

**Essential Reading:**


**Supplementary Reading:**


**Subject Code:** CS3305

**Subject Title:** Digital Signal Processing

**Prerequisites:** Basic Electronics

**Course Objectives:** To help the students to understand the basic concepts of signals and signal processing and its applications to various fields.

**Course Outcomes:** On successful completion of this course, the student will be able to:

1. formulate engineering problems in terms of DSP tasks;
2. apply engineering problem solving strategies to DSP problems;
3. design and test DSP algorithms
4. analyze digital and analog signals and systems;
5. recover information from signals;
6. encode information into signals;
7. design digital signal processing algorithms;
8. design and simulate digital filters;
9. analyze and compare different signal processing strategies.

**Course Contents:**

**UNIT -I: Signals and signal processing**

Characterization and classification of signals, Typical signal processing operations, Typical signal processing applications, Advantages of digital signal processing,

**UNIT -II: Time domain representations of signals and systems**

Discrete time signals, Operations on sequences, discrete time systems, Linear time invariant discrete time systems, Characterization of LTI systems

**UNIT-III: Transform domain representation of signals and systems**

The discrete time Fourier transform, the frequency response, the transfer function, Discrete Fourier series, Discrete Fourier transform, Computation of DFT Linear convolution using DFT, The z-transform, The region of convergence of z-transform

**UNIT -IV: Structures for discrete time systems**

Block diagram and signal flow representation of constant coefficient linear difference equation, Basic structures for IIR systems, Basic structures for FIR systems, Lattice structures, Effects of coefficient quantization, Effect of round off noise in digital filters, Zero-input limit cycles

**UNIT -V: Filter design techniques**
Design of discrete time IIR filters from continuous time filters, Design of FIR filters by windowing, Optimum approximation of FIR filters, Linear phase filters

UNIT -VI: Sampling of continuous time signals

Periodic sampling, Frequency domain representation of sampling, Reconstruction of bandlimited signal from its samples, Discrete time processing of continuous time signals, Continuous time processing of discrete time signals, Changing the sampling rate using discrete time processing

Essential Reading:

Supplementary Reading:

Subject Code: CS3406
Subject Title: System Software
Prerequisites: CS 341, CS 334
Course Objectives:
1. To identify software modules for small to large scale computing systems
2. To understand the language design principles & paradigms
Course Outcome:
1. Ability to design and develop efficient system software for different machine
2. Skills for efficient use of system software
Course Contents
System Software and Machine Architecture, IBM 360 Instruction Set Architecture and Assembly language programs, The simplified Instructional Computer, traditional (CISC) Machine, RISC Machines;
Language Processing: Assemblers, Cross assemblers, Macro processor, Single pass and multi pass, Linkers, Loaders, Relocating loaders and Direct linking loaders,
Compilers and Interpreters, Cross compilers, Lexical analyzer, Syntax analyzer, Intermediate and Machine code generation, Implementation Examples;
Formal grammars and languages, Software Tools for program Development, Editors, Debug Monitors, Programming Environments, user Interface.
Introduction to Operating Systems and Middleware
Essential Reading:
Subject Code: CS4107

Subject Title: Optimization Techniques

Prerequisites: MA 101, MA 202

Course Objectives:

1. This course is intended to provide students with a knowledge that can make them appreciate the use of various research operations tools in decision making in organizations.
2. At the end of the Course participants are expected to demonstrate a working knowledge of the various OR /OM tools in making decisions as well as being able to formulate organizational problems into OR models for seeking optimal solutions.

Course Outcomes:

1. Identify and develop operational research models from the verbal description of the real system.
2. Understand the mathematical tools that are needed to solve optimisation problems.
3. Use mathematical software to solve the proposed models.
4. Develop a report that describes the model and the solving technique, analyse the results and propose recommendations in language understandable to the decision-making processes in Management Engineering.

Course Content:

Origin, Characteristics and Techniques, operations research Modeling, Optimization Using Calculus: Stationary points; Functions of single and two variables; Global Optimum; Convexity and concavity of functions of one and two variables; Optimization of function of one variable and multiple variables; Gradient vectors; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Kuhn-Tucker Conditions; Examples

Linear Programming Constraints with less than equal to, equal to and greater than equal to types. Graphical method for two variable optimization problem. The Simplex method, Dual simplex method, Revised simplex method, Duality theory and sensitivity analysis. Transportation and Assignment problems, Traveling Salesman problem using branch and bound method, Network analysis including PERT-CPM, Integer programming, Non-linear
programming problem solving using Fibonacci search method, Golden ratio method, Gradient search method, Gradient projection method and Hessian matrix method. Integer Programming: Integer linear programming; Concept of cutting plane method; Mixed integer programming; Solution algorithms; Examples.

**Essential Reading:**


**Supplementary Reading:**


**Subject Code:** CS4108

**Subject Title:** Advanced Data Structures

**Prerequisites:**

**Course Objectives:**

**Course Outcomes:**

**Syllabus:**

**Essential Reading:**

1. 
2. 

**Supplementary Reading:**

1. 
2. 
Subject Code: CS4109
Subject Title: Advanced Database

Prerequisites: Data Structures and Algorithms, Database Management Systems

Course Objectives:

1. Understand and describe current and emerging database models and technologies
2. Understand the state-of-the-art in database management systems and distributed systems.
3. To make the students understand all requirement and operations that the analyst needed to analyze, design, and implement the systems
4. Apply database concepts to solve high-velocity and high-volume data problems.

Course Outcomes:

By the end of this module, students should be able to:

1. explain and evaluate the fundamental theories and requirements that influence the design of modern database systems
2. get acquaintance with major developments in advanced databases
3. hands on practice with no-sql tools

Course Contents:

Concurrency control and Transaction management, Database performance tuning, Distributed relational systems and Data Replication, Security considerations, Object oriented, deductive, spatial, temporal and constraint database management systems, New database applications and architectures: e.g. Data Warehousing; Multimedia; Mobility; Multidatabases; NoSQL, Native XML databases (NXD), Standards for interoperability and integration e.g. Web Services, SOAP, XML related specifications, e.g. XQuery, XPath, Cloud, Pig Latin, Logic/Deductive, Datalog OODBMS, OQL, XML and semistructured, XPath, XQuery. HDFS. Temporal and spatial databases, Data warehousing, distributed databases, Big Data Analytics, Advances in Database technolog

Essential Reading:

2. Eric Redmond, and Jim R Wilson, Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement, SPD publishers 2012

Supplementary Reading:

2. Bart Baesens, Analytics in Bigdata world, Wiley 2014
3. Rama Krishnan and Gehrke, Database Management systems, Mc Graw Hill,
Subject Code: CS4110

Subject Title: Internet and web Technology

Prerequisites:

Course Objectives:

Course Outcomes:

Syllabus:

Essential Reading:
1. 
2. 

Supplementary Reading:
1. 
2.
Subject Code: CS4111

Subject Title: Software Project, Process and Quality Management

Prerequisites:

Course Objectives:

2. Define roles and responsibilities by PM process group (initiating, planning, executing, controlling, and closing).

3. Articulate the purpose and benefits of project management (PM).

4. Written reports and oral presentations.

5. Work in groups to analyse a project and implement a solution.

6. Explain quality management and process improvement in the context of software development projects.

7. Apply key PM concepts.

8. Explain the project life cycle (concept, definition, execution, finish).

9. Apply estimating and risk management techniques to IS projects.

Course Outcomes:

1. This course and its outcomes support the Information Systems Learning Outcomes of Problem Solving and Critical Thinking (PS&CT), Communication and Interpersonal Skills (C&IS), and Ethical and Professional Responsibilities (E&PR).

2. These Information Systems Learning Outcomes are tied directly to the University Wide Outcomes of Critical Thinking and Problem Solving, Communication, and Values and Ethics.

Syllabus Description:

Introduction to S/W project management, S/W project management competencies, responsibilities of a software project manager, Software process, S/W process models, project planning, organization of project team, S/W size estimation, estimation of effort & duration, Halstead’s software Science, models, dependency & scheduling, staffing, Organizing a software engineering project, S/W configuration management, monitoring & controlling S/W projects, developing requirements, risk management, project tracking & control, communication & negotiating, S/W quality, S/W quality engineering, defining quality requirements, quality standards, practices & conventions, ISO 9000, ISO 9001, S/W quality matrices, managerial and organization issues, defect prevention, reviews & audits, SEI capability maturity model, PSP, six sigma

Essential Reading:


Supplementary Reading:

Subject Code: CS4212

Subject Title: Cryptographic Foundation

Pre-requisites: None

Course Objective:

1. To develop a mathematical foundation for the study of cryptography.
2. To Understand Number Theory and Algebra for design of cryptographic algorithms
3. To understand the role of cryptography in communication over an insecure channel.
4. Analyse and compare symmetric-key encryption public-key encryption schemes based on different security models

Course Outcomes:

1. Understand modern concepts related to cryptography and cryptanalysis.
2. Analyze and use methods for cryptography and reflect about limits and applicability of these methods.
3. Should be able to define the system to protect; determine the security properties that are desired for this system; identify the possible threats to these security properties, their likelihood of occurrence; and consider possible mitigations against these threats.
4. Describe and implement the specifics of some of the prominent techniques for public-key cryptosystems and digital signature schemes (e.g., Rabin, RSA, ElGamal, DSA, Schnorr)
5. Explain the notions of public-key encryption and digital signatures, and sketch their formal security definitions.

Course contents:

Unit I

*Classical cryptography and overview:* Classical cryptosystems and their cryptanalysis, Model of secure communication, Security services, Overview of attacks, X.800 Security Architecture for Open System Interconnection (OSI), and cryptanalysis

Unit II

*Cryptographic Techniques:* Introduction to Substitution Techniques, Transposition Techniques, Encryption and decryption, Symmetric and Asymmetric Key Cryptography, Steganography, Key Range and Key Size.

Unit III

*Mathematical background:* Introduction to Number theory, Modular arithmetic, prime number generation, GCD, Euclidean Algorithm, Extended Euclidean Algorithm, Chinese Remainder Theorem, Fermat’s and Euler’s Theorem

Unit IV


Unit V

*Public key cryptography:* RSA, ElGamal, DSA, Elliptic curve cryptosystems, Public Key Cryptography standard(PKCS), PKI, Digital Certificates, and Key management techniques.

Unit VI

**Essential Reading:**


**Supplementary Reading:**

2. Wade Trapple, Lawrence C. Washington- Introduction to Cryptography with coding Theory, 2nd Edition pearson Education

**Subject Code:** CS4213

**Subject Title:** Network Security

**Prerequisites:** Data Communication and Computer Networks

**Course Objectives:**

1. To familiarizes students with various type of attacks on the Computer Networks.
2. To manage secret key using certificate base key exchange and Public Key Infrastructure
3. To understand various security breached at application, transport and network level

**Course Outcomes:**

After completing this course the student must demonstrate the knowledge and ability to:

1. Design secure protocols at application, transport and network level
2. Analysis and design secure key management techniques
3. Design and analysis of secure wireless network protocols

**Course Contents**


**Essential Reading:**

Supplementary Reading:

Subject Code: CS4214
Subject Title: Information Theory and Coding
Prerequisites:
Course Objectives:
1. to define and apply the basic concepts of information theory (entropy, channel capacity etc.)
2. to study different types of channels in communication
3. to learn the principles and applications of information theory in communication systems
4. to study various data compression methods and describe the most common such methods
5. to understand the theoretical framework upon which error-control codes are built

Course Outcomes:
Up on successful completion of this course students should be able to:
1. quantify the notion of information in a mathematically sound way
2. explain what is the significance of this quantitative measure of information in the communications systems
3. calculate entropy, joint entropy, relative entropy, conditional entropy, and channel capacity of a system
4. differentiate between lossy and lossless compression techniques
5. decide an efficient data compression scheme for a given information source
6. explain the impact of feedback and/or many senders or receivers on the communication systems

Course Contents:

Essential Reading:
Subject Code: CS4215
Course title: Number Theory
Pre-requisites: None
Course Objective:
1. To present a rigorous development of Number Theory using axioms, definitions, examples, theorems and their proofs.
2. Help students understand the importance of mathematics in today’s world as well as furthering their mathematical development by tasking them to prove various theorems
3. Explore some current research problems in number theory
Course Outcomes:
1. Effectively express the concepts and results of Number Theory.
2. Understand the logic and methods behind the major proofs in Number Theory.
3. Appropriately integrate technology into mathematical processes.
4. Use mathematical concepts in problem-solving through integration of new material and modeling
Course Contents:

Unit I

Unit II

Unit III
*Congruence*: Linear Congruence, the Chinese Remainder Theorem, Divisibility Tests, Fermat’s Little Theorem, Pseudo primes, Euler’s Theorem.

Unit IV
*Multiplicative Functions*: The Euler Phi-Function, The Sum and Number of Divisors, Perfect Numbers and Mersenne Primes. Primitive Roots for Primes.

Unit V
*Quadratic Residues*: Quadratic Residues and Nonresidues. The Law of Quadratic Reciprocity.
Cryptography: Encrypt and decrypt a message using character ciphers. Learn to encrypt and decrypt a message using Public-Key cryptology.

Essential Reading:

Supplementary Reading:

Subject Code: CS4216
Subject Title: Wireless Sensor Networks
Prerequisites: Computer Networks

Course Objectives
- To obtain a broad understanding of the technologies and applications for the emerging and exciting domain of wireless sensor networks,
- To get in-depth hands-on experience in designing and developing a real operational embedded network system, and
- To design and develop foundational systems software, sensor-actuator-controller algorithms and network protocols.

Course Outcomes
By the completion of the course, the student should be able to
- Architect sensor networks for various application setups
- Compare analysis between performance and resources
- Assess coverage and conduct node deployment planning
- Determine suitable MAC protocol and radio hardware
- Design a secured, fault-tolerant, energy efficient routing protocol


Unit-III
Data Storage and Manipulation: Data centric and content based routing, storage and retrieval in network, compression technologies for WSN, Data aggregation techniques.
Essential Reading:


Supplementary Reading:


Subject Code: CS4217
Subject Title: Data Warehousing and Mining
Prerequisites: CS 102, CS 222, CS 332 (Data structures, DBMS, Algorithms)
Course Objectives:
1. To provide students with basic concepts in databases both in terms of usage and implementation
2. To make the students understand all requirement and operations that the analyst needed to analyze, design, and implement the systems
3. To design and build a simple database system and demonstrate competence with the fundamental tasks involved with modeling, designing, and implementation

Course Outcomes:
After completing this course the student must demonstrate the knowledge and ability to:
1. Aware of various database systems and its design issues
2. Design and implement a database for any specified domain according to well-known design principles that balance data retrieval performance with data consistency guarantees
3. Formulate data retrieval queries in SQL and the abstract query languages

Course Contents
Introduction to Data mining, Motivation for Data Mining, its importance, Role of Data in Data Mining, patterns in data mining, Type of patterns, visualization techniques, Data Mining Languages, and System Architectures, Applications, issues Data Warehousing: OLAP, Data models, extraction, transformation and loading, materializing views, indexing Association Rule Mining: Introduction, Support – confidence framework, apriori algorithm, DIC algorithm, hash based algorithm, FP growth tree, other measures of interest, cross rule mining Classification and Prediction: Decision tree, bayes classifier, Neural network, SVM, and other classifiers Cluster Analysis: Partitioned and hierarchical clustering, Outlier Analysis, other cluster tools Mining Complex Data, Applications and Trends in Data Mining Characteristics of data, Data privacy, Advances in data mining

Essential Reading:

**Supplementary Reading:**

**Subject Code:** CS4318

**Subject Title:** Bioinformatics

**Pre-requisite:** CS 332, CS 425

**Course Objectives:**
1. To understand protein information resources
2. To understand the genome information resources
3. To understand the DNA software analysis
4. To understand pair-wise alignment techniques
5. To understand multiple sequence alignment

**Course Outcomes:**
1. Learn about DNA and its sequences.
2. To get idea about DNA databases.
3. To understand pair-wise alignment techniques
4. Learn about biological databases.
5. To get idea about multiple software alignment.

**Syllabus Description:**
Genetics, Cell and Molecular Biology, Biochemistry, Introduction; Databases - mapping, sequence, structure, non-redundant; Sequence alignment - pair wise and multiple; phylogenetics; Structure prediction methods - homology, threading, abinitio; Sequence analysis - class and secondary structure prediction; motifs - PROSITE; detecting functional sites in DNA; OR Finder; Computer science perspective - pattern recognition, hidden Markov models; Data Miming Using Soft computing Techniques.

**Essential Reading:**

**Supplementary Reading:**
Subject Code: CS4319
Subject Title: Graph Theory and Network Algorithms

Pre-requisite:

Course Objective:

1. To understand the basic concepts of graphs and graph algorithms
2. To understand the BFS and DFS tree construction from graph
3. To understand the cuts and max flow of a graph

Course Outcome:

1. Applications of graph algorithms such as trees, walks, circuits to real world scenarios
2. To modelling the network as a graph and understand the graph traversal

Course Contents:

Introduction: Graphs, Isomorphism, Walks, Paths, Circuits, Trees, Properties of Trees, Cotrees and Fundamental Circuits, Cut Sets, Fundamental Cut Sets and Cut Vertices, Planar and Dual Graphs, Metric Representation of Graphs, Coloring and covering and partitioning of a graph, chromatic number, chromatic partitioning, chromatic polynomials, matching, covering, four color problem, Directed graphs, some type of directed graphs, Directed paths, and connectedness, Euler digraphs, trees with directed edges, fundamental circuits in digraph, matrices A, B and C of digraphs adjacency matrix of a digraph,, enumeration, types of enumeration, counting of labeled and unlabeled trees, polya’s theorem, graph enumeration with polya’s theorem.

Graph Algorithms: Elementary Graph Algorithms, Representations of graphs, Breadth-first search, Depth-first search, Topological sort, strongly connected components


Essential Reading:


Supplementary Reading:

Subject Code: CS4320
Subject Title: Image Processing
Prerequisites: Nil

Course Objectives:
The primary objective of this course is to introduce students to basic principles of digital images, image data structures, and image processing algorithms.

Course Outcomes:
1. Apply principles and techniques of digital image processing in applications related to digital imaging system design and analysis.
2. Analyze and implement image processing algorithms.
3. Gain hands-on experience in using software tools for processing digital images.

Course Contents:

UNIT - I Introduction
Elements of digital image processing systems, Vidicon and Digital Camera working principles, Elements of visual perception, brightness, contrast, hue, saturation, machband effect, Color image fundamentals - RGB, HSI models, Image sampling, Quantization, dither, Two-dimensional mathematical preliminaries, 2D transforms - DFT, DCT, KLT, SVD.

UNIT - II Image Enhancement
Histogram equalization and specification techniques, Noise distributions, Spatial averaging, Directional Smoothing, Median, Geometric mean, Harmonic mean, Contraharmonic mean filters, Homomorphic filtering, Color image enhancement.

UNIT - III Image Restoration

UNIT - IV Image Segmentation

UNIT - V Image Compression
Need for data compression, Huffman, Run Length Encoding, shift codes, Arithmetic coding, Vector Quantization, Transform coding, JPEG standard, MPEG.

Essential Reading:

Supplementary Reading:
Subject Code: CS4321

Subject Title: Artificial Intelligence

Prerequisites: Discrete Mathematics, Algorithm Analysis and Design, Database Management Systems

Course Objectives:
1. In this course, the students will learn some core AI ideas
2. The course concentrate on those topics that find applications in several different problem areas rather than in the context of specific applications.
3. To know about knowledge representation and its manipulation to get desired results.

Course Outcomes:

After completing this course the student must demonstrate the knowledge and ability to:
1. Design and implement AI techniques in the field of web search, speech recognition, machine translation, autonomous driving and scheduling etc.
2. Write natural language understanding program.
3. Solve complex problems using connectionist AI and symbolic AI

Course Contents

Basic concepts of AI; Problems in AI; Applications; Production systems; Problem solving methods; Forward vs backward reasoning; Search in state spaces, state-space graph, uninformed search, heuristic search, general graph search algorithms, 2-agent games; knowledge representation using predicate calculus; rules of inference; converting arbitrary wff to conjunction of clauses, resolution reputation system and direct system; answer extraction; Natural language processing: ATN,case grammar, semantic grammar, frame structure and script: Non-monotonic reasoning, truth mentenance system, Connectionist AI; Introduction to expert system..

Essential Reading:
2. N. J. Nilsson, Principles of Artificial Intelligence, Narosa

Supplementary Reading:
1. S. Russel and P. Norvig, Artificial Intelligence: a Modern Approach, Pearson,
2. D. W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India

Subject Code: CS4322

Subject Title: Soft Computing

Prerequisites:

Course Objectives:

This course will present the basics of Soft computing and its application areas particularly to intelligent systems. Topics that will be discussed include SC and hybrid intelligent systems, neurofuzzy systems.

Course Outcomes:

Upon completion of the course, the students should be able to
1. Identify and describe soft computing techniques and their roles in building intelligent machines
2. Recognize the feasibility of applying a soft computing methodology for a particular problem
3. Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems
4. Apply genetic algorithms to combinatorial optimization problems
5. Apply neural networks to pattern classification and regression problems
6. Effectively use existing software tools to solve real problems using a soft computing approach
7. Evaluate and compare solutions by various soft computing approaches for a given problem.

Course Contents


Essential Reading:

Supplementary Reading:

Subject Code:CS4323

Subject Title: Pattern Recognition

Prerequisites:

Course Objectives:
1. To make the student aware of Pattern Recognition techniques and its practical applications.

Course Outcomes:

After completing the course, the student will
1. know basic structure of pattern recognition systems
2. know the statistical bases of the classification theory (the Bayes classifier)
3. distinguish supervised learning methods from the unsupervised ones
4. be able to apply supervised learning methods (model-based maximum likelihood, k-nearest neighbors) to the classifier design
5. be able to apply various clustering algorithms.

Course Details:
UNIT -I Overview of Pattern classification and regression, Introduction to Statistical Pattern Recognition, Overview of Pattern Classifiers,

UNIT -II Bayesian decision making and Bayes Classifier, The Bayes Classifier for minimizing Risk Estimating Bayes Error; Minimax and Neymann-Pearson classifiers

UNIT – III Parametric Estimation of Densities, Implementing Bayes Classifier; Estimation of Class Conditional Densities, Maximum Likelihood estimation of different densities, Bayesian estimation of parameters of density functions, MAP estimates, Bayesian Estimation examples; the exponential family of densities and ML estimates, Sufficient Statistics; Recursive formulation of ML and Bayesian estimates

UNIT -IV Mixture Densities and EM Algorithm, Mixture Densities, ML estimation and EM algorithm Convergence of EM algorithm; overview of Nonparametric density estimation

UNIT – V Nonparametric density estimation, Convergence of EM algorithm; overview of Nonparametric density estimation, Nonparametric estimation, Parzen Windows, nearest neighbor methods

UNIT – VI Linear models for classification and regression, Linear Discriminant Functions; Perceptron -- Learning Algorithm and convergence proof, Linear Least Squares Regression; LMS algorithm AdaLinE and LMS algorithm; General nonlinear least-squares regression, Logistic Regression; Statistics of least squares method; Regularized Least Squares, Fisher Linear Discriminant, Linear Discriminant functions for multi-class case; multi-class logistic regression

UNIT -VII Overview of statistical learning theory, Empirical Risk Minimization and VC-Dimension Learning and Generalization; PAC learning framework, Overview of Statistical Learning Theory; Empirical Risk Minimization, Consistency of Empirical Risk Minimization, Consistency of Empirical Risk Minimization; VC-Dimension, Complexity of Learning problems and VC-Dimension, VC-Dimension Examples; VC-Dimension of hyperplanes, UNIT - VIII Artificial Neural Networks for Classification and regression, Overview of Artificial Neural Networks, Multilayer Feedforward Neural networks with Sigmoidal activation functions; Backpropagation Algorithm; Representational abilities of feedforward networks, Feedforward networks for Classification and Regression; Backpropagation in Practice, Radial Basis Function Networks; Gaussian RBF networks, Learning Weights in RBF networks; K-means clustering algorithm,

UNIT-IX Support Vector Machines and Kernel based methods, Support Vector Machines -- Introduction, obtaining the optimal hyperplane, SVM formulation with slack variables; nonlinear SVM classifiers, Kernel Functions for nonlinear SVMs; Mercer and positive definite Kernels, Support Vector Regression and ε-insensitive Loss function, examples of SVM learning, Overview of SMO and other algorithms for SVM; ν-SVM and ν-SVR; SVM as a risk minimizer, Positive Definite Kernels; RKHS; Representer Theorem

Essential Reading:
1. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification (2nd ed) John Wiley & Sons, 2006

Supplementary Reading:
2. Christopher M. Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1st Ed, 2003
Subject Code: CS4324

Subject Title: Machine Learning

Prerequisites:

Course Objectives

1. To understand the basic building blocks and general principles that allow one to design machine learning algorithms
2. To become familiar with specific, widely used machine learning algorithms
3. To learn methodology and tools to apply machine learning algorithms to real data and evaluate their performance

Course Outcomes:

1. Explain the principles, advantages, limitations such as overfitting and possible applications of machine learning
2. Identify and apply the appropriate machine learning technique to classification, pattern recognition, optimization and decision problems.
3. Develop an appreciation for what is involved in learning from data.
4. Understand how to apply a variety of learning algorithms to data.
5. Understand how to perform evaluation of learning algorithms and model selection.

Course Contents:

Introduction to ML (1 Hr), Review of probability and statistics (2 Hr), Supervised learning (1 Hr):A case study, Bayes decision theory (2 Hrs), Multivariate Gaussian density and discriminant function (1 Hr), Regression (Logistic and linear) (2Hr), Density estimation (parametric and Non parametric) (5Hrs) Decision Trees (1Hrs) Linear Discriminant Function (2Hrs), ANN(MLP) (3 Hrs) Unsupervised learning (3Hrs)( clustering, etc..), Dimensionality reduction( PCA, LDA, MDA) (3 Hrs), SVM (2Hrs),HMM (3 Hrs), Ensemble methods: Bagging, boosting. Evaluating and debugging learning algorithms. Reinforcement learning and control. (4 Hr) MDPs. Bellman equations. Value iteration and policy iteration. Linear quadratic regulation (LQR). QG. Q-learning. Value function approximation. Policy search. Reinforce. POMDPs.

Essential Reading:


Supplementary Reading:

1. Lecture notes in Machine Learning, Zdravko Markov

Subject Code: CS4325

Subject Title: Natural Language Processing

Prerequisites: Basic knowledge of probabilities, Algorithms

Course Objectives:

1. To apply fundamental algorithms and techniques in the area of NLP.
2. Understand approaches to syntax and semantics in NLP.
3. Understand approaches to discourse, generation, dialogue and summarization within NLP.


5. Understand machine learning techniques used in NLP, including hidden Markov models and probabilistic context-free grammars, clustering and unsupervised methods, log-linear and discriminative models, and the EM algorithm as applied within NLP.

Course Outcomes:

1. Perform PoS tagging in for a given text
2. Apply Machine learning techniques to extract information from text
3. Apply NLP techniques in various real world application

Course content:

Words and Word Forms : Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields.

Structures : Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Hybrid of Rule Based and Probabilistic Parsing; Scope Ambiguity and Attachment Ambiguity resolution.

Meaning : Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors; Coreferences.

Web 2.0 Applications : Sentiment Analysis; Text Entailment; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).

Sound : Biology of Speech Processing; Place and Manner of Articulation; Word Boundary Detection; Argmax based computations; HMM and Speech Recognition.

Essential Reading:


3.

Supplementary Reading:


Subject Code: CS4326

Subject Title: Robotics

Prerequisites: Mathematics (Linear Algebra, Vector Spaces etc.), Computer Controlled System Embedded Programming

Course Objectives:

1. This course is intended to provide students with knowledge of complex concepts of Artificial Intelligence in the field of robotics and explore high quality research in different areas of information technology.
2. Enable our students to excel in the area of robotics and cognitive sciences to produce robotics software and make robotics framework to the development of social robotics field.

Course Outcomes:

1. Students will be familiarized with the robot programming & various robotics framework.
2. Students will be familiarized with the working principles of various Sensors and actuators and their applications in robots.
3. Students will have good knowledge about various types of Industrial robot, Humanoid Robot, and their design concepts with working methodologies.
4. Students will be familiarized with social robotics applications through humanoid robot.

Course Content:

Introduction to robotics, classification of robots, Spatial orientation transformation-Eulerian and quaternion representation, Homogenous Coordinate Transformation Matrix and its inversion principle, Forward and Inverse Kinematics Problem, D-H Principle, modeling principle of a Cyber physical system, manipulator jacobian and singularity, Examples of inverse manipulator kinematics, repeatability and accuracy, robot modeling using its dynamics- both N-E and Lagrangian method, Trajectory planning, robot control principle- basic master slave control architecture, PD-PID control, computed torque/model based methodology, nonlinear control, sensory devices for robots-both external and internal sensors, sensory information fusion using D-S theory, Robot programming- both offline and real time programming methodologies.

Biped Locomotion Control: Inverted Pendulum model, Compass gait model, Equation of motion of Linear Inverted pendulum & simple pendulum. Concept of ZMP, COP, COM, orbital energy. General control architecture of a Humanoid Robot

Essential Reading:


Supplementary Reading:


Subject Code: CS4327

Subject Title: Human Computer Interaction

Prerequisites: Basic Programming

Course Objectives: The objective of this course is
1. to give an introduction to the key areas, approaches and developments in the field.
2. to get student to think constructively and analytically about how to design and evaluate interactive technologies.
3. Basically, the course will introduce them to key areas, theoretical frameworks, approaches and major developments in HCI.

**Course Outcomes:**

Upon completion of the course, Students will be able to:

1. Explain the capabilities of both humans and computers from the viewpoint of human information processing.
2. Describe typical human–computer interaction (HCI) models, styles, and various historic HCI paradigms.
3. Apply an interactive design process and universal design principles to designing HCI systems.
4. Describe and use HCI design principles, standards and guidelines.
5. Analyze and identify user models, user support, socio-organizational issues, and stakeholder requirements of HCI systems.
6. Discuss tasks and dialogs of relevant HCI systems based on task analysis and dialog design.
7. Analyze and discuss HCI issues in groupware, ubiquitous computing, virtual reality, multimedia, and Word Wide Web-related environments.

**Syllabus:**

**Unit 1: Foundations of Human–Computer Interaction**

8. Section 1: Human Capabilities
9. Section 2: The Computer
10. Section 3: The Interaction
11. Section 4: Paradigms

**Unit 2: The Design Process**

- Section 1: Interaction Design Basics
- Section 2: HCI in the Software Process
- Section 3: Design Rules
- Section 4: Universal Design

**Unit 3: Implementation Support**

- Section 1: Implementation Tools

**Unit 4: Evaluation and User Support**

- Section 1: Evaluation
- Section 2: User Support
Unit 5: Users Models

- Section 1: Cognitive Models
- Section 2: Socio-organizational Issues and Stakeholder Requirements

Unit 6: Task Models and Dialogs

- Section 1: Analyzing Tasks
- Section 2: Dialog Notations and Design

Unit 7: Groupware, Ubiquitous Computing, Virtual and Augmented Reality, Hypertext and Multimedia

- Section 1: Groupware and Computer-supported Collaborative Work
- Section 2: Ubiquitous Computing
- Section 3: Virtual Reality and Augmented Reality
- Section 4: Hypertext, Multimedia and the World Wide Web

Essential Reading:


Supplementary Reading:


Subject Code: CS4328

Subject Title: Information Retrieval

Prerequisites: CS2007 Database Engineering

Course Objectives:

1. To make students aware of how search engines work
2. To make students conversant with rank systems
3. To make students learn underlying architecture

Course Outcomes:

The students will be able to evaluate a retrieval system, and can design a retrieval system for specific application need.

Syllabus:


**Essential Reading:**

**Supplementary Reading:**

**Subject Code:** CS4429

**Subject Title:** Ad-hoc and Wireless Networks

**Prerequisites:**

**Course Objectives**
1. To study about the basics of wireless networks.
2. To understand the challenges in wired vs. wireless domain in computer networks.
3. To study about various types of wireless networks, i.e., cellular networks, Bluetooth, Ad hoc networks and wireless sensor networks.

**Course Outcomes:**
Upon completion of this module, students will be able to:
1. Understand the underlying technologies of wireless networks.
2. Specify and identify deficiencies in existing wireless protocols for MAC layer and Network layer, and then go onto formulate new and better protocols.
3. Understand the technology behind the cellular network, installation of base station, Bluetooth etc.
4. To master the concepts of ad hoc networks and the design / performance issues in wireless local area networks and wide area networks.
5. To be familiar with contemporary issues in networking technologies.

**Course Contents**

**Essential Reading:**

**Supplementary Reading:**

**Subject Code:** CS4430  
**Subject Title:** Distributed Operating Systems  
**Prerequisites:**

**Course Objective:** To understand the concepts of distributed systems and programming paradigm for distributed systems  

**Course Outcome:** Ability to design and implement distributed systems for industry, research and society  

**Course Contents**


*Operating Systems for Parallel Computers:* Operating Systems for parallel computers, Performance Parameters & Evaluation of parallel computers  

*Distributed System Principles:* Characterization of distributed systems, Design goals, Communication and computer networks, Distributed processing, Distributed operating systems, Client Server Communications, Remote Procedure calls, Marshalling  

*Distributed Services:* File Service, Name Service, Distributed transactions and concurrency control, Synchronization & Coordination, Distributed Algorithms  

*Fault Tolerance & Security:* Fault tolerance and security in Distributed Systems, System Level Diagnosis, Agreement protocols  

*Parallel & Distributed Programming:* PVM, MPI, Globus  

**Essential Reading:**

**Supplementary Reading:**
Subject Code: CS4431

Subject Title: Multi-core Architecture and Programming

Prerequisites: Computer Organization & Architecture, Operating Systems

Course Objectives:
- To understand the recent trends in the field of Computer Architecture and identify performance related parameters
- To appreciate the need for parallel processing
- To expose the students to the problems related to multiprocessing
- To understand the different types of multicore architectures
- To understand the concepts of multi-threading and OPENMP

Course Outcomes:
The students should be able to:
- Identify the limitations of ILP and the need for multi-core architectures.
- Solve the issues related to multiprocessing and suggest solutions.
- Point out the salient features of different multi-core architectures and how they exploit parallelism.
- How to program multicore processors

Syllabus:


Essential Reading:

Supplementary Reading:

Subject Code: CS4432
Subject Title: Advanced Computer Architecture
Prerequisites:

Course Objective:
1. To identify the key components of a computing system
2. To model the parallel programming paradigm

Course Outcome:
1. Ability to evaluate the performance of new computing systems
2. Ability to interface and integrate new equipments to the existing protocols and standards

Course Contents
Metrics for computer performance: clock rate, MIPS, CPI; Strength and weakness of performance metrics; role of Amdalh's in computer performance; Classification of computer architecture: SIMD, MIMD, SISD and MISD; Processing unit design: Data path implementation, Microprogrammed execution.

Pipelining: Instruction pipelining and parallel processing, Instruction level parallelism: VLIW, Vector processor, Multithreaded processor, Superscalar architecture; branch prediction; Prefetching; Speculative execution; Principles of pipelining and vector processing: Pipelining, Instruction and Arithmetic Pipelines, Principles of Designing Pipelined Processor,


Essential Reading:


**Supplementary Reading:**

**Subject Code:** CS4433

**Subject Title:** Embedded Systems

**Prerequisites:** Digital Electronics, Computer Organisation and Architecture, Microprocessor and microcontroller, assembly language programming, programming in C/C++.

**Course Objectives:**
1. To encourage students to learn basics of embedded systems
2. Demonstration of an integrated view how processor, I/O and network can work together in an embedded system

**Course Outcomes:**
1. The students will be able to decide the requirements of hardware and software to solve a problem depending on speed of operation, energy efficiency and design cost.
2. The students can use the knowledge acquired from this course to design real time and safety critical systems

**Course Contents:**
Introduction: Embedded system, Processor, hardware units, software embedding, SOC, NOC, VLSI circuit; Device and Device drivers, I/O devices, timer and counting devices, serial communication using IC, LAN and advanced I/O buses between the networked multiple devices, Host system, parallel communication using ISA, PCI, PCI-X, and advanced buses, device drivers, parallel port device drivers in a system, serial port device drivers. Interrupt service handling mechanism; Software and programming concepts: processor and memory selection for embedded system, embedded programming in C++, Java and UML, multiple processes and applications, problem of sharing data by multiple tasks and routines, interposes communication; Real time OS: OS services, I/O subsystem, Network OS, Real-time Embedded system, Need of well tested and debugged RTOS, Introduction to C/OS-II. Case Studies of programming with RTOS: Smart card embedded system, Hardware and Software co-design: specification and design of an embedded system, use of software tools for development of an embedded system. Low power design of embedded systems.

**Essential Reading:**

**Supplementary Reading:**

**Subject Code:** CS4434

**Subject Title:** Cluster and Grid Computing

**Pre-requisite:** CS 334, CS 421, CS332

**Course Objective:**
1. To learn the high performance computing systems such as cluster, grid and cloud
2. To understand the concept of fault tolerance in distributed systems

**Course Outcome:**
1. Skills to design and develop parallel and distributed algorithm
2. Ability to program clusters and grids
3. Ability to install COTS components

**Course Contents**


*Cluster*: Cluster Components-Processor/machine, High Speed Interconnections-goals, topology, latency, bandwidth, Example Interconnect: Myrinet, Infiniband, QsNet, Fast Ethernet, Gigabit Ethernet, Light weight Messaging system/Light weight communication Protocols, Cluster Middleware-Job/Resource Management System, Load balancing, Scheduling of parallel processes, Enforcing policies, GUI, Introduction to programming tools such as PVM, MPI, Cluster Operating Systems Examples: Linux, MOSIX, CONDOR.

*Grids*: Characteristics of Grid, Computational services, Computational Grids, Data grids/Storage grids, management and applications, Different components of Grid-Grid fabric, Grid middleware, Grid applications and portal, Globus toolkit Ver.2.4, web services, MDS, GRAM, Grid Security –Cryptography, Authentication, Integrity, Digital Signature, Digital Certificates, Certificate Authority, MD-5, RSA, GSI,GSSAPI, Directory Service, LDAP,GRID FTP,GASS
Introduction to Clouds: Characteristics and design goals of cloud, Service oriented infrastructure, Data centers, Server & storage virtualization, different types of clouds, Cloud environment, Cloud Programming

Fault Tolerance: Fault detection and diagnosis of Clusters, Grids & Clouds, reliability & availability

Essential Reading:

Supplementary Reading:

Subject Code: CS4435

Subject Title: Parallel Algorithms

Prerequisites:

Course Objectives:
To be aware of parallel programming

Course Contents:

Essential Reading:
1. B. Wilkinson & M. Allen, Parallel Programming, Pearson, 2nd Ed, 2005

Supplementary Reading:
Subject Code: CS4436  
Subject Title: VLSI System Design  
Prerequisites: Basic Electronics, Digital Electronics

Course Objectives:
1. To teach the students the basics of VLSI design  
2. Expertise the students in designing digital circuits with MOS transistors

Course Outcomes:
1. The students will be able to design hardware components at transistor level.

Course Contents:
Deep sub-micron digital IC design; Transistors and Devices: MOS transistors; Bipolar transistors and circuits; Fabrication: IC fabrication technology; Simulation: Modeling the MOS transistor for Circuit Simulation; Silicon-on-Insulator technology; MOS Inverter circuits: Voltage transfer characteristics; Noise margin definitions; NMOS transistors as load devices; CMOS inverter. Static MOS Gate circuits: CMOS gate circuits; Complex CMOS Gates; XOR and XNOR Gates; Flip-Flops and Latches; Semiconductor memory design: MOS decoder; Static RAM cell design; SRAM column I/O circuitry; Power Grid and Clock design: Power distribution design; clocking and timing issues; Phase-locked loop/Delayed-locked loop. Low power design techniques.

Essential Reading:

Supplementary Reading:

Subject Code: CS4437  
Subject Title: Mobile Computing  
Prerequisites: Data Communication, Computer networks

Course Objectives:
1. To teach the students the basics of mobile computing.

Course Outcomes:
1. Students will have the basic knowledge on different aspects of mobile computing.
Course Contents:

Overview of wireless and mobile systems (wireless LANs, cellular systems, sensor networks, etc.) and the challenges therein. The radio channel and wireless physical layer design. Medium access, multiplexing, link adaptation. Multihop routing protocols, routing metrics. Multicast, multihop data forwarding, opportunistic routing. Solutions to handle mobility at various layers of the networking stack. TCP behavior over wireless, other transport layer issues. Energy efficiency, localization, security. Smartphone-based platform architectures and applications. Future directions: dynamic spectrum access, heterogeneous networks, internet of things.

Essential Reading:


Supplementary Reading:


Subject Code: CS4438

Subject Title: Cloud Computing

Prerequisites:

Course Objectives:

1. Understand Cloud Computing concepts, technologies, architecture and applications.
2. Understand the underlying principle of cloud virtualization, cloud storage, data management and data visualization.
3. Understand different cloud programming platforms and tools to develop and deploy applications on cloud.

Course Outcomes:

Upon successful completion of this course students should be able to:

1. Develop and deploy cloud application using popular cloud platforms
2. Design and develop highly scalable cloud-based applications by creating and configuring virtual machines on the cloud and building private cloud.
3. Make recommendations on cloud computing solutions for an enterprise.

Course Contents:


Cloud Computing Architecture - Cloud computing stack; Service Models (XaaS): Infrastructure as a Service(IaaS), Platform as a Service(PaaS), Software as a Service(SaaS); Deployment Models: Public cloud, Private cloud, Hybrid cloud. Data Center Architecture.

Cloud Resource Virtualization - Introduction to virtualization; Different approaches to virtualization; Hypervisors; Machine Image; Virtual Machine(VM); Process VM vs System VM; Resource Virtualization: Server, Storage, Network; Full Virtualization vs Para Virtualization; Operating System Support for Virtualization; Virtual Machine(resource) Provisioning and Manageability; Virtual Machine Migration.

Service Management in Cloud Computing - Service Level Agreements(SLAs); Billing & Accounting; Economics of scaling; Managing Data: Database & Data Stores in Cloud, Large Scale Data Processing.
Task Scheduling in Cloud - Scheduling Algorithms for Computing Clouds; Fair Queuing; Start Time Fair Queuing; Borrowed Virtual Time; Cloud Scheduling Subject to Deadlines; Scheduling MapReduce Applications Subject to Deadlines.


Case Study - Microsoft Azure, Amazon EC2

Essential Reading:


Supplementary Reading:


Subject Code: CS4439

Subject Title: Internet of objects

Prerequisites:

Course Objectives:

Course Outcomes:

Syllabus:

Essential Reading:

1.

2.

Supplementary Reading:

1.

2.
Subject Code: CS4440

Subject Title: Fault Tolerant Distributed Systems

Prerequisites: Computer Architecture and Operating System

Course Objectives:
1. To identify the types of faults and fault behavior in distributed systems
2. To develop fault detection, diagnosis and recovery algorithms

Course Outcomes:
1. Implementation of fault tolerant algorithms
2. Performance evaluation of fault tolerant algorithms

Course Contents:
Types of faults: Hard, Transient, Intermittent and Byzantine Faults
Causes of Faults: Environment, Out of range, Physical damage
Fault Model: PMC Model, BGM, MM, MM* and comparison models
Fault Detection and Diagnosis: System level diagnosis, Centralized Vs. Distributed Diagnosis, Static Vs. Dynamic Diagnosis, Diagnosis Algorithms, Asymptotic Complexity, Diagnosable systems, t diagnosability, k-connectivity, diagnosis parameters, Replica Management, K+1 Redundancy
Fault Isolation and Fault Recovery: Fault tree, Isolation and Recovery Algorithms
Fault Evaluation: Diagnosis Latency, Diagnosis Start-up Time, False Alarm Rate and Message Complexity
Applications: Fault Diagnosis for distributed systems such as Clusters, Grids, Internet and Cloud.

Essential Readings:

Supplementary Readings:

Subject Code: CS4441

Subject Title: Low Power Systems

Prerequisites: Basic Electronics, Digital Electronics, Computer Organization and Architecture, Microprocessor, Embedded System, VLSI System design

Course Objectives:
1. To encourage students in designing low power systems.
2. Teach power optimization techniques at circuit, architectural and algorithmic levels.

**Course Outcomes:**
1. Students will have basic knowledge in designing energy efficient hardware and software.

**Course Contents:**
Introduction, historical background that led to the development of present-day VLSI circuits, importance of low power in high-performance and battery-operated embedded systems, MOS Fabrication Technology, MOS Transistors, MOS Inverters, MOS Combinational Circuits, Sources of Power Dissipation, Supply Voltage Scaling for Low Power, Switched Capacitance Minimization, Leakage Power Minimization, Adiabatic Logic Circuits, Battery-Aware Systems, Software optimization techniques for low power.

**Essential Reading:**

**Supplementary Reading:**
communication (AM, FM), Introduction to digital communication (Sampling, PAM, PCM, PPM, PWM, Modulation and demodulation techniques ), Communication Networks, Introduction to Mobile Communication (Lecture notes to be provided)

Text Book (Essential Reading):
1. Microelectronic Circuits, Oxford University Press, S. Sedra and K. C. Smith; Sixth edition
3. Digital Fundamentals, Floyd, Pearson Education India; 10 edition

Reference:

Course Outcomes:
At the end of the course, the student must be able to
1. Design of various diode circuits
2. Design simple transistor amplifier and other circuits
3. Design simple combinational and sequential circuits
4. Design circuits using ideal Op-amp to perform mathematical operations on analog signals
5. Realize the importance of various analog and digital electronic systems, and electronic

Course Coordinator: Prof. S. H. Hiremath

<table>
<thead>
<tr>
<th>EC 2001</th>
<th>ANALOG ELECTRONICS</th>
<th>4 Credits [3-1-0]</th>
</tr>
</thead>
</table>

Pre-requisites: EC 1000: Basic Electronics

Bipolar Junction Transistor: Small Signal model, BJT biasing for discrete circuit design, single stage amplifier analysis, complete static characteristic, internal capacitances and second order effect.; Field-Effect Transistor: MOSFET as amplifier, biasing of MOS amplifier circuits, single stage IC-MOS amplifiers, MOSFET as analog switch, Small signal model of MOSFET for high and low frequencies.; Spice model and analysis of FET circuits.; Frequency Response Analysis: S-domain analysis, Bode plot, amplifier transfer function, low frequency and high frequency response of common-source and common drain amplifiers, Current Mirrors, Cascode Amplifier.; Feedback Amplifier: General feedback structures, negative feedback, the 4 basis feedback topologies and their analysis, close loop gain calculation, Oscillators.; Output stage and Power Amplifier: Classification of output stages, Class A, Class B, Class AB amplifiers; Differential and Multistage Amplifier: BJT differential amplifier, non-ideal characteristics of differential amplifier, multistage amplifiers. Phase Locked Loops: Simple PLL Operation, Applications.
Course Outcome: Develop the art of analog and mixed signal integrated design. Make students well versed with the fundamental building blocks of analog IC.

Course Coordinator: Prof. K.K. Mohapatra

**EC 2002** DIGITAL ELECTRONICS 3 Credits [3-0-0]

Pre-requisites: EC 1000: Basic Electronics


Essential Reading:

Supplementary Reading:

Course outcomes: It will help one student in understanding the basic logic circuits and the design procedure for building up digital systems.

Course Coordinator: Prof. K.K. Mohapatra

**EC 2005** NETWORK ANALYSIS AND SYNTHESIS 3 Credits [2-1-0]


**Essential Reading:**

**Supplementary Reading:**

**Course Outcome:**

**Course Coordinator**: Prof. S Deshmukh

**EC 2302 ELECTRICAL AND ELECTRONICS MEASUREMENT** 3 Credits [3-0-0]


**Essential Readings:**

**Supplementary Readings:**

**Course Outcome**: A graduate student should able to understand the basic principles of the electrical and electronics measurement instruments and use them to measure the appropriate quantities.

**Course Coordinator**: Prof. S. Kar

**EC 2502 ELECTROMAGNETIC THEORY** 3 Credits [3-0-0]

Laplace and Poisson’s equation, Solution of Laplace equation by separation of variables in Cartesian, cylindrical and spherical co-ordinates, cylindrical and spherical harmonics, Examples.; Maxwell’s equations for static fields, their modifications for time-varying fields conducting and dielectric media.; EM Wave equations and uniform plane waves, in free space and in lossy medium, wave propagation in good dielectrics, in good conductors: Depth of penetration, Poynting vector and power flow, Reflection and refraction of EM Waves.; Transmission lines: Transmission line equations, Parameters- primary and secondary constants, Reflection coefficient and SWR, Matched Transmission line, Impedance matching, Smith chart problems, Analogy of transmission lines with e. m. waves.; Guided waves and Waveguides: Electric and magnetic fields in rectangular waveguide; TE, TM and TEM modes, Dominant modes, \( \lambda c, \lambda g, Vp, Vg \), Numerical examples.; Radio Wave Propagation: Modes of propagation, Structure of Troposphere, Tropospheric Scattering, Ionosphere, Ionospheric Layers - D, E, F1, F2, regions. Sky wave propagation - propagation of radio waves through
Ionosphere, Effect of earth’s magnetic field, Virtual height, Skip Distance, MUF, Critical frequency, Space wave propagation.

**Essential Readings:**

**Supplementary Reading:**

**Course Outcome:** Solving of numerical problems related to Maxwell’s equations, Electromagnetic Waves, Poyenting Theorem etc. Derivation of equations for Transmission line, VSWR, Reflection Coefficient Design and development of Transmission Line circuits using Smith chart, rectangular waveguides. Analysis of a problem and find solution to the same Study the effect of environments viz: Ground wave, Space wave and Sky wave Propagations

**Course Coordinator:** Prof S K Behera

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**EC 2601 SIGNALS AND SYSTEMS 3 Credits [2-1-0]**


**Essential Reading:**

**Supplementary Reading:**

**Course Outcome:**

**Course Coordinator:** Dr. Samit Ari

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**EC 2700 BASIC ELECTRONICS LABORATORY 2 Credits [0-0-3]**
Pre-requisite: Basic Electronics (EC 1000)

1. Familiarization with basic electronic instruments and identification of different passive (resistor, inductor, capacitor and potentiometer) and active (diodes, BJTs and FETs) components.
2. Study of Electronic Equipment (Power Supply, Multimeter, Function Generator and DSO)
   (i) Measurement of AC and DC voltages and currents and resistances by Digital Multimeter.
   (ii) Study of Digital Storage Oscilloscope (DSO) and Function Generator: Connection, Display and Measurement of various types of periodic signals (sine, square, triangular).
3. Study of static V-I characteristic of Semiconductor diode and Zener diode
4. Study of different types of Rectifiers using junction diode and filter circuit.
5. Study of input and output characteristics of BJT and determination of the Q-point and load line, input resistance (Ri), Output Resistance (Rout).
6. Study of an RC coupled CE transistor amplifier and determination of its gain, bandwidth and signal handling capacity.
7. Verification of the frequency response of Passive and Active high pass and low pass filters.
8. Study of Input and output characteristics of FET and determining the Pinch-off Voltage (Vp) and Idss.
9. Study of different DC and AC bridges.
10. Study and characterization of resistive/inductive/ capacitive/ peizo-electric sensors.
11. Study of input and output characteristics of FET and determining the Pinch-off Voltage (Vp) and Idss.
12. Mini project: To design and test a small circuit (amplifier, oscillator, filter: any one)

Course Outcomes:

1. Students will be able to understand the characteristics and the working principles of electronic devices e.g. Diode, Zener Diode, BJT, JFET.
2. Students will be able to design and develop electronic circuits e.g. Rectifiers, Clipper, Clamper, Filters, Amplifiers and Operational Amplifiers etc.
3. Students will be able to identify digital logic gates and be able to design simple combinational circuits using gates
4. Students will be able to understand the characteristics different sensors and use them in sensing environment like process control

Course Coordinator: Prof. A.K.Swain

EC 2701 CIRCUIT SIMULATION LABORATORY 1 Credit [0-0-2]

Course Outcomes: To develop and analyze the various analog electronic circuits like rectifiers, filters, amplifiers using BJT and Op-Amps in multisim software and P-spice simulation platforms.

Course Coordinator: Prof. K.K.Mohapatra

EC 2702: DIGITAL ELECTRONICS & HDL LAB 2 Credits [1-0-2]
Introduction to Digital Hardware, Introduction to Cad Tools, Introduction to VHDL.; Data types, Behavioral, Structural and dataflow styles of design, Implementation details for FPGAs.; Synthesis of a logic function by NAND gates only. (Minimized and two level).

**Course outcomes:** It will provide a practical experience in design and analysis of the basic circuits for the digital architecture and knowhow of VHDL language for design of digital circuits.

**Course Coordinator:** Prof. K.K.Mohapatra

<table>
<thead>
<tr>
<th>EC 2703</th>
<th>ANALOG ELECTRONICS LABORATORY</th>
<th>2 Credits [0-0-2]</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Familiarization with basic electronic instruments and identification of different passive (resistor, inductor, capacitor and potentiometer) and active (diodes, BJTs and FETs) components Study of Electronic Equipment (Power Supply, Multimeter, Function Generator and DSO) (i) Measurement of AC and DC voltages and currents and resistances by Digital Multimeter. (ii) Study of Digital Storage Oscilloscope (DSO) and Function Generator: Connection, Display and Measurement of various types of periodic signals (sine, square, triangular).</td>
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<tr>
<td>2.</td>
<td>Study of static V-I characteristic of Semiconductor diode and Zener diode</td>
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<td>3.</td>
<td>Study of different types of Rectifiers using junction diode and filter circuit.</td>
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<td>4.</td>
<td>Study of input and output characteristics of BJT and determination of the Q-point and load line, input resistance (Ri), Output Resistance (Rout).</td>
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<td>5.</td>
<td>Study of an RC coupled CE transistor amplifier and determination of its gain, bandwidth and signal handling capacity.</td>
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<td>6.</td>
<td>Verification of the frequency response of Passive and Active high pass and low pass filters.</td>
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<tr>
<td>7.</td>
<td>Study and characterization of resistive/inductive/ capacitive/ piezo-electric sensors.</td>
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<td>8.</td>
<td>Implementation of the equation using two operational Amplifier (IC741) ( Vo = -5V1+2V2-10V3 ). Use minimum value of resistor as 10K.</td>
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<tr>
<td>10.</td>
<td>Design a Wien Bridge Oscillator using OP-Amp and verify its operation 5. Cascade Amplifier A. To understand the basic principle of operation and to determine the Voltage gain and bandwidth</td>
<td></td>
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<tr>
<td>12.</td>
<td>To study the Voltage Control Oscillator(VCO) A. Design voltage control Oscillator B. Determine the amplitude of Triangular and square wave Oscillator. C. Determine the Square and triangular wave oscillator by varying the different circuit parameter.</td>
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<tr>
<td>13.</td>
<td>Realization of Phase Locked Loop(PLL) A. Determination of free running frequency. B. Determination of Locked Range Frequency (FLH-FLL) C. Determination of Capture Range Frequency(FCH-FCL)</td>
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<tr>
<td>14.</td>
<td>Digital to Analog Converter (D/A) A. Using R-2R Ladder network B. Input of Ladder network will connect with 4-bit ripple counter output.</td>
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</tr>
</tbody>
</table>
C. Measure and draw the output DC by CRO

15. Analog to Digital Converter (A/D)
   A. Successive approximation type

16. Design a Dual mode DC Regulated power supply (±6V).

Essential Reading:

Supplementary Reading:

Course Outcome:

Course Coordinator: Prof. K.K. Mohapatra

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EC 2704 ELECTRONICS DESIGN LABORATORY 1 Credit [0-0-2]

A. Design a Push-Pull Amplifier.
B. Measure Dc Bias voltage in each stage.
C. Draw and measure the AC input and output of voltage of each stage (input, push-pull, output stage)
D. Measure the frequency response and bandwidth.
E. Calculate the efficiency (η) of this amplifier.

Topics for the Mini Project

Essential Reading:


Supplementary Reading:

Course Outcome:

Course Coordinator: Prof D P Acharya

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EC 3001 SEMICONDUCTOR DEVICES 3 Credits [3-0-0]

Prerequisites: EC 1000: Basic Electronics

Energy Bands and charge carriers in semiconductors: Energy bands, direct and indirect semiconductors, Electrons and holes, Intrinsic and extrinsic materials, Fermi-Dirac distribution function, electron and holes concentrations at equilibrium, space charge neutrality, conductivity and mobility, Hall effect

Excess carriers in semiconductors: Drift, Diffusion: Current equation, Einstein’s Relationship, Continuity equation; Generation & Recombination: Mechanisms, Minority Carrier Lifetime; P-N junction: Principles, DC model, Capacitance of Reverse bias PN junction, store charge effects, Metal Semiconductor contacts: Schottky diode, Ohmic Contact MOS Capacitor; MOSFET: Principles, C-V Characteristics, Second order effects; BJT: Principles, C-V Characteristics, Second order effects; IC Technology: Bipolar IC Technologies; MOSFET Technologies; BICMOS Technologies Microwave FETs & Diodes; IGBT, Thyristors.

Essential Reading:

Supplementary Reading:


Course Outcome: Students learn the semiconductor device basics such as BJT, MOSFET and BICMOS

Course Coordinator: Prof D P Acharya.
Pre-requisite: EC 2001: Analog Electronics


Essential Reading:

Supplementary Reading:

Course Coordinator: Prof. S Kar.
Inverters: Single phase half bridge and full bridge inverter, 3-phase inverter-180 degree and 120-degree conduction mode, Pulse Width Modulated Switching scheme for voltage control, SPWM and modified SPWM of 1-phase inverters, PWM with unipolar and Bipolar Voltage Switching, PWM in 3-phase VSI, Square wave operation, Switching Utilisation. Harmonic reduction by programmed harmonic elimination switching, Forced Commutated Thyristor Inverters, Auxiliary Commutated (Mc-Murray) Inverter, Complementary Commutated (Mc-Murray-Bedford) inverter, Current Source Inverter, Single phase CSI Inverter Circuit Design.

Essential Reading:

Supplementary Reading:

Course Outcome: Students learn the power electronic device basics

Course Coordinator: Prof K.K.Mohapatra

EC 3201 MICROPROCESSORS AND MICROCONTROLLERS 3 Credits [3-0-0]

Architecture of the 8086/8088 microprocessor, Internal operations, Maximum mode, Minimum mode of operation, Addressing modes, Instruction Format, Instruction execution timing, 8088 vs 8086, Assembly Language Programming: Data Transfer instruction, Arithmetic and Logical instructions, String Manipulation instructions etc needed for ALP, Modular programming: Simple assembler directives and operators, Linking and relocation, Stack, Procedures, Interrupt, Macro, Programming examples. Byte and string manipulation, I/O programming, 8087 Numeric data processor and its use in the 8086/8088 system, 8089 I/O processor (IOP), Architecture, Communication between CPU & IOP. Arithmetic Coprocessor, MMX and SIMD Technology; Bus interface, The 80386/80486/Pentium/Pentium II/Pentium III/Pentium IV Microprocessors;

8051 Microcontroller: Architecture, Instruction, Programming and Interfacing

Essential Reading:

Supplementary Reading:

Course Outcome: The students will have the knowledge of microprocessors and microcontrollers and their applications.

Course Coordinator: Prof S K Patra

EC 3202 EMBEDDED SYSTEMS 3 Credits [3-0-0]

INTRODUCTION TO 8-bit and 16-bit microcontroller: 8051 family of microcontroller, architecture, memory organization, special function registers, timer counter, serial interface, interrupt organization, instruction sets and programming, instruction timing and interfacing, practical applications, introduction to 16-bit microcontroller 8096.

INTRODUCTION TO Embedded systems, Processor and memory organization, Devices and Buses for device networks, I2C Bus, SPI Bus, PCI bus, Device drivers and Interrupt servicing mechanism, Programming concepts and Embedded programming in C and C++, Program modeling concepts in single and multiprocessor- development Process, Real time operating system.

Essential Readings:


**Supplementary Readings:**


**Course Outcome:** Knowledge of basic design of embedded systems in different platforms with special emphasis to 8051.

**Course Coordinator:** Prof D.P. Acharya

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**EC 3301**

**CONTROL SYSTEMS**

3 Credits [3-0-0]

**ENGINEERING**


**Essential Reading**

1. K. Ogata, *Modern Control Engineering*, Pearson Education

**Course Outcome:** A graduate should be able to analyse and design stable processes/plants using Nyquist criteria, Routh-Hurwitz criteria, Bodeplot and Root Locus technique, etc.

**Course Coordinator:** Prof. T.K. Dan

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**EC 3302**

**ELECTRONIC INSTRUMENTATION**

3 Credits [3-0-0]

**Pre-requisite:** EC 1000: Basic Electronics

**REVIEW OF MEASUREMENTS AND ERROR:** Definition, accuracy and precision, Significant figures, Types of error, Statistical analysis, Probability of error, limiting error; CATHODE RAY OSCILLOSCOPE: Introduction, Block diagram of CRO, cathode ray tube, CRT circuits, Vertical deflection system, delay line, horizontal deflection systems, Multipletrace, Oscilloscope probes and transducers, Measurements with CRO, special oscilloscope.;

**SIGNAL GENERATION:** Sine-wave generator, Frequency synthesized signal generator, Frequency divider generator, Sweep frequency generator, pulse and square wave generator, Function generators, Audio frequency signal generator, Digital and Analog Noise generator

**SIGNAL ANALYSIS:** Wave analyser, Distortion analyser and spectrum analyser; FREQUENCY AND TIME INTERVAL MEASUREMENT: Simple frequency counter, measurement error, extending frequency range of counter, Automatic computing counter, Measurement of higher frequency by wave meter, heterodyne freq. meters; ANALOG AND DIGITAL DATA ACQUISITION SYSTEMS: Introduction, Signal conditioning of input, Single channel data acquisition systems, Multi-channel data acquisition systems, Data conversion, A/D and D/A
converters, Multi-plexers, Sample and hold circuits; INPUT OUTPUT DEVICES AND DISPLAY: Introduction, Analog displays and recorders, Digital I/O devices, Displays, Display multiplexing, Zero suppressing.

Essential Readings:

Supplementary Readings:

Course Outcome: A graduate should be able to understand Electronic instrumentation, be familiar with CRO, Function Generator, Data acquisition System and their uses.

Course Coordinator: Prof. B. Mukherjee

**EC 3303 INSTRUMENTATION DEVICES 3 Credits [3-0-0]**


LOADING EFFECTS IN MEASUREMENT SYSTEM: Electrical loading, Generalized loading. SIGNAL AND NOISE IN MEASUREMENT SYSTEM: Statistical representation of random signals: Effects of Noise and interference on Measurement circuits, Noise sources and coupling mechanism, Method of reducing effects of Noise and interference. SENSING ELEMENTS: Resistive (Potentiometers, Resistance Thermometer, Strain Gauges), Inductive (Variable reluctance, LVDT), Capacitive (variable area, gap, dielectric), Magnetic type (eddy current, magnetostrictive, magnetoresistive), Thermoelectric, Elastic, Piezoelectric, Photoelectric, Hall effect, Synchros.

SIGNAL CONDITIONING CIRCUITS: Potentiometer Circuit (constant voltage and constant current), Wheatstone Bridge (constant voltage and constant current), Instrumentation Amplifier.

Essential Readings:

Supplementary Readings:

Course Outcome: A graduate should be able to analyse the generalized Measurement System and be able to design the different types of sensor (i.e. Resistive, Inductive, Capacitive, Piezoelectric, Thermoelectric etc.) as well as sensing condition element (i.e. Associate bridge circuit etc.).

Course Coordinator: Prof. S. Kar

**EC 3304 PROCESS CONTROL 3 Credits [3-0-0]**

Pre-requisite: EC 3301: Control System Engineering

INTRODUCTION TO PROCESS CONTROL: A Process Control System, Important terms and the objectives of Automatic Process Control, Transmission Signals, Control Strategies; MATHEMATICAL TOOLS: Deviation variables, Linearization of functions of one variable, Linearization of functions of two or more variables; FIRST-ORDER DYNAMIC SYSTEM: Thermal Process, Dead time, Level process, Response of first-order processes; HIGHER-

Essential Reading:


Supplementary Readings:

Course Outcome: A graduate should be able to model and analyse first order and higher order, design of P, PI and PID controllers and design of single loop feedback control system.

Course Coordinator: Prof. U.C.Pati

EC 3306 FOUNDATIONS OF ELECTRONIC INSTRUMENTATION

Pre-requisite: EC 1000: Basic Electronics

REVIEW OF MEASUREMENTS AND ERROR: Definition, accuracy and precision, Significant figures, Types of error, Statistical analysis.
CATHODE RAY OSCILLOSCOPE: Introduction, Block diagram of CRO, cathode ray tube, Deflection amplifier, waveform display, CRO time base, Dual trace and multi trace CRO, Multiple trace, voltage, frequency and phase measurements, Oscilloscope probes and transducers, Measurements with CRO; special oscilloscopes - limited to delayed time base CRO, sampling CRO, Digital storage CRO, DSO application.
SIGNAL GENERATION: Low frequency signal generator, function generator, Pulse generator, RF signal generation, sweep frequency generation, frequency synthesizer and arbitrary waveform generator, Digital and Analog Noise generator.
SIGNAL ANALYSIS and MISCELLANEOUS INSTRUMENTS: X-Y recorders and plotter, Distortion meter, Spectrum Analyzer, True RMS meter, Low level voltmeter
FREQUENCY AND TIME INTERVAL MEASUREMENT: Simple frequency counter, measurement error, extending frequency range of counter, Automatic computing counter, Measurement of higher frequency by wave meter, heterodyne freq. meters.

An introduction to virtual instrumentation through LABVIEW

(Block diagram approach would be adopted wherever necessary)

Essential Readings:


Supplementary Readings:

Course Outcome: On completion of the course a student should be able to provide principles of different instruments leading to design of instruments and evaluate performance of different instruments.

Course Coordinator: Prof. S.K. Behera

EC 3501 PRINCIPLES OF COMMUNICATION SYSTEMS 3 Credits [3-0-0]

SPECTRAL ANALYSIS: Fourier series, Response of a linear system, Normalized power in a Fourier expansion, Power spectral density. The Fourier transform, Convolution, Parseval’s theorem, Power and energy transfer through a network, Auto and Cross correlations.

AMPLITUDE MODULATION SYSTEMS: Frequency translation, Recovery of base band signal, Amplitude Modulation, Maximum Allowable Modulation. The square law demodulator, Spectrum of AM signal, Balanced Modulator, SSB modulation and generation, VSB, FDM.


NOISE IN COMMUNICATION SYSTEM: Resistor noise, Available power, Noise temperature, Noise bandwidth, Two ports Noise bandwidth, Input Noise temperature, Noise figure, Equivalent-Noise temperature of a cascade; example of receiving system.

Essential Readings:

Supplementary Reading:

Course Outcome:

Course Coordinator: Prof S Deshmukh

EC 3502 DIGITAL COMMUNICATION 3 Credits [3-0-0]

ANALOG TO DIGITAL CONVERSION: Pulse Modulation Systems, Sampling theorem, Pulse Amplitude Modulation, Quantization of signals, Quantization error, Pulse code modulation (PCM) system, Companding, Time division multiplexing (TDM), DPCM, DM, ADM.

DIGITAL MODULATION TECHNIQUES: BPSK, DPSK, DEPSK, QPSK, M-ary PSK, BFSK, M-ary FSK, M-QAM, MSK, GMSK.

OPTIMUM RECEIVERS FOR AWGN CHANNEL: Optimum receiver for signals corrupted by AWGN, performance of optimum receiver for memory less modulation, optimum receiver for CPM signals, optimum receiver for signals with random phase in AWGN channel.


CHANNEL CAPACITY AND CODING: Channel models and channel capacity, Block codes – coding and decoding, cyclic codes, algebraic codes, Reed-Solomon Code, Convolutional codes;

SPREAD SPECTRUM SIGNALS FOR DIGITAL COMMUNICATION: Direct sequence (DS) spread spectrum and its applications, frequency hopping (FH) spread spectrum, synchronization of spread spectrum systems.

Essential Readings:

Supplementary Reading:

Course Outcome:

Course Coordinator: Prof S Deshmukh

**Supplementary Readings:**

**Course Outcome:** A graduate student will be able to design and develop Digital LTI systems, FIR and IIR filters, FFT algorithms, etc.

**Course Coordinator:** Prof. A.K. Sahoo

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**EC 3701 MICROPROCESSORS LABORATORY**

2 Credits [1-0-2]

Architecture of the 8086/8088 microprocessor, Internal operations, Maximum mode, Minimum mode of operation, Addressing modes, Instruction Format, Instruction execution timing, 8088 vs 8086; Assembly Language Programming: Data Transfer instruction, Arithmetic and Logical instructions, String Manipulation instructions etc needed for ALP, Modular programming: Simple assembler directives and operators, Linking and relocation, Stack, Procedures, Interrupt, Macro, Programming examples.

**PART A** (Programming)

**PART B** (Interfacing)

**PART C** (Mini Project – One to be done): Work not limited to the list

**Course Outcomes:** The students would learn the hardware and software development using a microprocessor and hence make digital systems using that device.

**Course Coordinator:** Prof. A. K. Swain

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**EC 3702 EMBEDDED SYSTEM DESIGN LABORATORY**

2 Credits [0-0-3]

Study of 8051 architecture, Study the different addressing modes: Immediate, Register, Direct, Register Indirect and Indexed.
Write an Assembly and C language programming for the following: To transfer data from code ROM space into RAM locations, RAM locations to other RAM locations. Find the largest element in an array stored in the internal RAM location, and display the result in port2. ALP to sort an array stored in the internal ram location. To experiment with a look-up table. Addition hex numbers. Program to add BCD numbers. Add two multi-byte BCD numbers. 8051 division and multiplication instructions.

To examine the I/O port operation using a simulator. To trace through a CALL subroutine using a simulator. To write a program to convert data from hex to ASCII. Write a program to find the average of a set of hex data. Study of On Chip Peripherals: Timers, Serial Port & Interrupts Interfacing of 8051 with modules such as: LCD, 4x4 Hex Keypad, ADC, DAC, Stepper Motor & Sensors, Real Time clock

**Tools Used:** KEIL Microvision IDE, 8051 development boards

**Course Outcome:** The students will learn basic system design techniques with emphasis on hardware and software. Learn efficient interfacing of the I/O devices in making an embedded system.

**Course Coordinator:** Prof. D. P. Acharya
### EC 3703  COMMUNICATION ENGINEERING LABORATORY  2 Credits [0-0-3]

1. Study and design of AM modulator and demodulator. (Full AM, SSB, DSBSC, SSBSC)
2. Using MATLAB generate a carrier and a modulating signal. Modulate the carrier using AM. Show the modulated waveform in time domain and analyze its frequency spectrum. Repeat the simulation for modulating signal being square, triangular and other forms of waveform.
4. Using MATLAB generate a carrier and a modulating signal. Modulate the carrier using FM. Show the waveform in time domain and analyze its frequency spectrum. Repeat the simulation for modulating signal being square, triangular and other forms of waveform.
5. Using Lab-View software simulate AM modulation and demodulation system.
6. Using Lab-View software simulate FM modulation and demodulation system.
7. Design a receiver to demodulate and receive the signal from a AM radio station.
8. Design a receiver to demodulate and receive the signal from the local FM radio station.

**Course Coordinator:** Prof. P Singh

### EC 3704  DIGITAL COMMUNICATION LABORATORY  2 Credits [0-0-3]

2. Observe the process of quantization and determination of quantization noise.
3. Different channel coding and decoding techniques.
4. Generation and reception of ASK using hardware.
5. Generation and reception of BPSK.
6. Generation and reception of QPSK.
7. Generation and reception of BFSK
8. Simulation of different modulation schemes using Matlab.
9. Experimentally compare different forms of BPSK, QPSK, OQPSK and analyze their spectrum with spectrum analyzer.

**Course Coordinator:** Prof. P Singh

### EC 3705  DIGITAL SIGNAL PROCESSING LABORATORY  1 Credit [0-0-2]

1. Write a program for linear convolution of two sequences.
2. Write a program for circular convolution.
3. Write a program to perform linear convolution using circular convolution.
4. Write a program to perform N-point DFT. Also perform the IDFT on the result obtained to verify the result.
5. Write a program to perform circular correlation using
   (a)Direct method b) using circular convolution.
6. Write a program to perform circular convolution and correlation using DFT.
7. Write a program to perform linear convolution using (a) overlap save method (b) overlap add method.
8. Write a program to perform FFT on a sequence using the following methods. (a) Decimation in time (b) Decimation in frequency
9. Write a program to perform IDFT on a transformed sequence using DFT.
10. Write a program to design an FIR filter using windowing technique.

11. Write a program to design an IIR filter using (a) impulse invariant method (b) bilinear transformation method.

**Course Outcome:** This course will help one student to analyze time and frequency domain signals and the filters in engineering problems.

**Course Coordinator:** Prof. A.K. Sahoo.

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**EC 3706 INSTRUMENTATION DEVICES** 2 Credits [0-0-3]

<table>
<thead>
<tr>
<th>Determination of Temp. - Resistance &amp; Temp. — Voltage characteristics of the Thermistor; Determination of Temp-Resistance &amp; Temp. — Voltage characteristics of the RTD (pt-100); Determination of Temp. using Thermocouple with compensation &amp; without compensation. Plot the graph for Actual Temp. vs % Error; Determination of characteristics between strain applied &amp; the voltage output, as well as the signal conditioned voltage of a cantilever strain gauge; To study the characteristics of a LVDT with respect to secondary output voltage &amp; Signal conditioned output voltage. Calibrate the LVDT &amp; plot the graph between displacement &amp; % Error; To study the response of optical sensor by varying the distance from light source; Study of PID controller; Study of Temperature control system</th>
</tr>
</thead>
</table>

**Course Outcome:** Student can able to design a various Measurement system using sensors and signal conditioning elements and can able to calibrate the system.

**Course Coordinator:** Prof. T.K. Dan

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**EC 3707 COMMUNICATION SYSTEM DESIGN** 2 Credits [0-0-3]

**Course Coordinator:** Prof. P Singh

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**EC 3708 CONTROL SYSTEM** 2 Credits [0-0-3]

**Course Outcome:** Student can able to simulate the different types of control schemes and its tuning through the control system trainer as well as can design the Compensator.

**Course Coordinator:** T.K. Dan

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**EC 4201 VLSI DESIGN TECHNIQUES** 3 Credits [3-0-0]

**Prerequisites:** EC 2002: Digital Electronics

Introduction to VLSI Design, Levels of abstraction and the complexity of design, Challenges of VLSI design: power, timing, area, noise, testability, reliability and yield; CAD tools: simulation, layout, synthesis, test; MOS modeling, MOS device models, Short-channel effects and velocity saturation, Scaling of MOS circuits; VLSI fabrication technology, Layout design, Design rules, Stick diagrams; The CMOS inverter, VTC, Switching behavior, Noise margins and power
dissipation; Static and dynamic CMOS combinational logic gate, Transistor sizing in static CMOS, logical effort, Pass-transistor logic, sizing issues, Domino logic gates, estimating load capacitance, Simple delay models (RC) for CMOS gates, Power consumption; Latches and clocking, Flip-flops, Set-up and hold tests, Static and dynamic latch and flip-flop, Clock design; Datapath units, Adders, Shifters, Multipliers; Control logic strategies, PLAs, Multi-level logic, Synthesis and place-and-route CAD; MOS memories, Register, SRAM, DRAM; Global interconnect modeling, Capacitance, resistance and inductance of interconnect; Signal and power-supply integrity issues, Electromigration, RC interconnect modeling Driving large capacitive load, reducing RC delays; Layout design, Standard-cell layout, Chip layout and floor planning, Array layout; Implementation issues, Design for testability, Packaging technology, I/O issues: ESD protection, boundary scan, inductance, synchronization

**Essential Reading:**

**Supplementary Reading:**

**Course Outcome:** To develop the knowledge of VLSI and digital integrated circuits. Students can design and analyze different logic style based digital circuits such as NAND, NOR, MUX, Flip-flops, Registers, Counters, RAM, ROM. Draw and design the CMOS compatible layouts of the above circuits.

**Course Coordinator:** Prof K.K. Mahapatra

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**EC 4202  EMBEDDED COMPUTING SYSTEMS  3 Credits [3-0-0]**

Microcomputer-based Systems, Software Development, Interfacing Methods, Interrupt Synchronization, Threads, Timing Generation and Measurements Serial I/O Devices, Parallel Port Interfaces, Memory Interfacing, High Speed I/O Interfacing Analog Interfacing Data Acquisition Systems, Microcomputer-based Control Systems Simple Networks, Digital Filters. **Circuits and DSP Architectures:** Circuit design basics, deep submicron issues, low architectures for embedded systems. **Architecture Design:** Embedded processor architectures, Architectural techniques for low power, Design methods for core based ASICs. **Compiler and OS:** Introduction to compiler optimizations, Power models for compiler optimizations, Code size vs. performance / power trade offs. **DSP Algorithm Design:** A/D conversion and finite precision analysis, Algorithms for embedded systems: source and channel processing, Portable embedded code. **Networking:** Networking basics (addressing and routing), Wireless vs. wire-line networking, Distributed OS for networked embedded systems: Case study of JINI.

**Essential Reading:**

**Supplementary Reading:**
2. Proceedings of the IEEE (Special Issue on HW/SW Codesign), March, 1997.

**Course Outcome:** To develop the knowledge of embedded computing system. Student can learn and design embedded products using 8051 and ARM processors, peripherals like Timer, LCD, UART, and bus protocols like ISA, CAN, LIN, I2C.

**Course Coordinator:** Prof K.K. Mahapatra
**EC 4203  IoT and Applications  3 Credits [3-0-0]**


Analysis of some Real World Use CasesCase Studies Illustrating IoT design e.g. Smart Lighting, home intrusion detection, smart parking, smart irrigation, forest fire detection.

**Essential Reading:**
Designing the Internet of Things by Adrian McEwen and Hakim Cassimally, Wiely, 2015

**Supplementary Reading:**
Internet of Things: A hands on Approach by A.Bahga and V.Madisetti, Universities Press, 2015

**Course Outcome:** To develop the knowledge of internet of things, the hardware and software of devices connecting to internet server.

**Course Coordinator:** Prof D.P.Acharya

**EC 4205  RECONFIGURABLE SYSTEM DESIGN  3 Credits [3-0-0]**

**Prerequisites:** EC 2002: Digital Electronics


Basic concepts of hardware description languages (VHDL , Verilog HDL), logic and delay modeling, Structural, Data-flow and Behavioral styles of hardware description, Architecture of event driven simulators, Syntax and Semantics of VHDL, Variable and signal types, arrays and attributes, Operators, expressions and signal assignments, Entities, architecture specification and configurations, Component instantiation, Concurrent and sequential constructs, Use of Procedures and functions, Synthesis of logic from hardware description.


Introduction to scripting Languages: Perl, Tcl.

**Essential Reading:**


3. Latest Resources from Xilinx and ALTERA web sites
Supplementary Reading:
1. J.Bhasker, A VHDL Primer,
2. J.Bhasker, A Verilog Primer,

Course Outcome: Create the knowledge of HDL and high level VLSI design

Course Coordinator: Prof D.P.Acharya

EC 4301 INDUSTRIAL INSTRUMENTATION 3 Credits [3-0-0]


Essential Reading

Supplementary Reading
2. A.K. Ghosh; Introduction to Instrumentation and Control; Prentice Hall of India, 2011.

Course Outcome: A graduate should be able to understand & design different sensors for measurement of different physical variables like pressure, temperature, flow and level.

Course Coordinator: Prof. U.C.Pati

EC 4302 PC BASED INSTRUMENTATION 3 Credits [3-0-0]

Introduction: Generalized instrumentation system, PC-Based instrumentation system. Principles of data acquisition: Sampling concepts, Digital to analog converters, Analog to digital converters, Data acquisition systems, Data acquisition configurations. Hardware Organization of IBM PC: Motherboard components, System resources, Expansion buses and I/O ports, Peripherals. Plug-in Data Acquisition and Control Boards: Plug-in boards, General purpose plug-in DAQ board, PCI plug-in DAQ board. Data Acquisition using GPIB: Overview of GPIB, GPIB commands, GPIB programming, Expanding GPIB, SCPI. Data Acquisition using Serial Interfaces: Serial communication, Serial interface standards, PC serial port, USB,
IEEE1394, Remote I/O modules. **Networked Data Acquisition:** Network data communication, Local area networks, HART communication, Field buses, **Recent developments.**

**Essential Reading**
1. N. Mathivanan; PC-Based Instrumentation: Concepts and Practice; Prentice-Hall of India, New Delhi, 2011.
2. H.S. Kalsi; Electronic Instrumentation; Tata-McGraw Hill Education.

**Supplementary Reading**
Mike Tooley ; PC-Based Instrumentation and Control; Newnes – An Imprint of Butterworth-Heinemann, 2008.

**Course Outcome:** A graduate should be able to understand and design data acquisition & control system using local data acquisition, GPIB data acquisition, data acquisition using serial interfaces, networked data acquisition, DCS, SCADA and PLC.

**Course Coordinator:** Prof. U.C.Pati

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**EC 4303 BIOMEDICAL INSTRUMENTATION 3 Credits [3-0-0]**

**Pre-requisite:** EC 336: Industrial Instrumentation

**INTRODUCTION:** Generalized Medical Instrumentation System, Roles of Engineering in Healthcare systems, Biometrics, Problems encountered in measuring physiological parameters; **PHYSIOLOGICAL TRANSDUCERS:** Various types of transducers for measurement of temperature, pressure, flow etc. and their selection for medical applications, Different types of electrodes, **BIO-ELECTRIC SIGNALS AND ELECTRONICS:** Origin of bioelectric signals, Bioelectric potentials, Biopotential electrodes; **CARDIOVASCULAR MEASUREMENT:** Electrocardiograph, Measurement of ECG, ECG electrodes, ECG Amplifiers, Common mode interference reduction circuits, Cardiac pacemaker, Phonocardiograph, Measurement of heart rate, Plethysmography, Blood pressure measurement, **BLOOD FLOW METERS:** Electromagnetic blood flow meter, Ultrasonic blood flow meter, Doppler flow meter; **Measurement of electrical activities in muscles and brain:** Electroencephalograph, Electromyograph and their interpretations. Measurement of temperature, **Respiratory System Measurement:** Respiration rate measurement, Lung Volume and Capacity, Spirometer, Ventilators, **Instrumentation for Clinical laboratory:** **BLOOD GAS ANALYZERS:** Blood pH Measurement, Pulse oximeter, **BLOOD CELL COUNTERS:** Coulter counters, Automatic recognition and differential counting of cells, GSR measurement; Medical Imaging: Ultrasonography, X-ray.

**Essential Readings:**

**Supplementary Readings:**

**Course Outcome:** A graduate should be able to understand bioelectric signals and design suitable transducers, understand and use the functioning of biomedical recorders, patient monitoring system and blood cell counters.

**Course Coordinator:** B. Mukherjee
EC 4305  ANALYTICAL INSTRUMENTATION  3 Credits [3-0-0]

Introduction; Instruments for optical Spectroscopy- Components of optical instruments, Radiation sources, wavelength selector, sample containers, Radiation detectors. An introduction to Molecular ultraviolet/visible and near Infrared Absorption Spectroscopy- Quantitative aspects of Absorption measurements, Instruments for Absorptive Measurements in the UV, visible & near IR region. Application of Molecular UV/visible Absorption Spectroscopy; Infrared Absorption Spectroscopy-IR sources & detectors, IR instruments, FT spectroscope; Mass spectroscopy; Gas chromatography; PH measurement; Moisture & humidity Measurement

Essential Reading:

Supplementary Reading:

Course Outcome: A graduate should be able to analyse the different types of sample (i.e. solid, liquid and gas) from a mixture by using different types of techniques (i.e. Chromotography, Spectrography(UV, IR, Visible), FT spectroscopy, Mass Spectroscopy etc).

Course Coordinator: Prof. T.K. Dan

EC 4306  OPTICAL INSTRUMENTATION  3 Credits [3-0-0]

OPTICAL FIBRES: STRUCTURES WAVE GUIDING AND FABRICATION: Optical laws and definitions, Optical fiber modes and configurations, Mode theory for circular wave guides, Single-mode fibers, Grade index fiber structure; ATTENUATION AND DISPERSION: Attenuation, Signal dispersion in fibers; OPTICAL SOURCES: LEDs, Lasers, Principle of emission, Modes of resonant cavity, Q-switching, Mode locking, Gas, solid state, semiconductor and liquid lasers; POWER LAUNCHING AND COUPLING: Source to fiber power launching, Lensing schemes for coupling improvement, Fiber to fiber joints, LED coupling to single mode fibers, Fiber splicing, Optical fiber connectors; PHOTODETECTORS: Photo detector noise, Detector response time, Avalanche multiplication noise, PIN diodes, APD; FIBER OPTIC SENSORS: Intensity modulated sensors, Phase modulated sensors, Frequency modulated sensors, Wavelength modulated sensors, Polarisation modulated sensors, Scattering loss modulated sensors; ADVANCED TOPICS.

Essential Reading:

Supplementary Reading:

Course Outcome: A student can be able to understand fundamentals of optical fiber, sources, detectors and coupling. He will also be able to know about optical fiber based sensors for the measurement of different variables like displacement, force, strain, vibration, temperature, pressure etc.

Course Coordinator: Prof. U.C. Pati

EC 4308  VIRTUAL INSTRUMENTATION  3 Credits [3-0-0]

Pre-requisite: EC 4301: Industrial Instrumentation

Introduction to Virtual Instrumentation, Basics of LabVIEW, Loops, The structures, Arrays and Clusters, Graphs and Charts, State Machines, File Input/Output, String Handling, Data Acquisition with LabVIEW DAQ VIs, Interfacing with Assistants, Interfacing Instruments, Advanced Topics in LABVIEW.

Essential Reading:
Course Outcome: A graduate should be able to understand virtual instrumentation, be familiar with LabVIEW programming, acquiring data with LabVIEW and interfacing different instruments.

Course Coordinator: Prof. U. C. Pati.

EC 4309 ADVANCED PROCESS CONTROL 3 Credits [3-0-0]

Feed forward & Ratio Control - Introduction; Ratio Control; Feed forward Controller design based on steady state models; Feed forward controller design based on dynamic models; Relationship between the steady state & Dynamic design methods, configuration for feed forward-feedback control; Tuning feed forward controllers. Enhanced single loop control strategies –Cascade Control, Time delay compensation, Inferential control, selective OVERRIDE control, Adaptive control. Multi loop & Multi variable control -Process interaction & control loop interaction; pairing of controlled & manipulated variables, Tuning of multi loop PID control system, Decoupling & multi variable control strategies; Strategies for reducing control loop interaction. Model predictive control-Multi variable, optimization problems, Dynamic matrix control, Other MPC method Internal Model Control-Introduction; Open loop controller Design; Model uncertainty and disturbances, IMC structure; IMC design; Effect of Model uncertainty & disturbances. IMC based PID procedure- Equivalent feedback form to IMC; IMC based feedback design with Time delay as well as without time delay; IMC based PID controller design for stable and unstable processes; Plantwide Control.

Essential Reading:
1. Process dynamics & control by Dale E.Sebarg,Thomas F. Edgar ;John Wiley & Son
2. Process Control Modeling, Design & Simulation by B.wayne Bequette ; PHI

Course Outcome: A graduate should be able to analyse and design different process control strategies applied in process units (i.e. stabiling from Feedback, Feed-forward, Cascade, Ratio control, Split range control, Inferential control, IMC and DMC etc).

Course coordinator: Prof. T.K.Dan.

EC 4501 ANTENNA ENGINEERING 3 Credits [3-0-0]


Essential Readings:

Supplementary Reading:
**Course Outcome:** Study of antenna parameters viz: Radiation resistance, Antenna resistance, Bandwidth, Beam width, Radiation pattern, Radiation intensity, Gain - Power gain Directive gain, Directivity, Antenna aperture, Efficiency, Effective aperture, effective length, Polarization Design and analysis of Short wire antenna, Half-wave Dipole antenna, Yagi antenna etc Study the working principles of Horn antenna and parabolic antenna Design and analysis of Microstrip antenna along with its various parameters Solving problems related to the above cases

**Course Coordinator:** Prof S K Behera

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**EC 4502 CODING THEORY AND SECURED COMMUNICATION 3 Credits [3-0-0]**

**Introduction to cryptography:** Notions of cryptographic secrecy; Block ciphers; Stream ciphers; Public-key cryptography; Iterated and cascade ciphers; Cryptanalysis; Implementation attacks; Complexity theory; Authentication and identification; Ownership protection; Covert communications

**The integers:** Basic number theory; The Euclidean algorithm; Prime fields; Quadratic residues; Quadratic reciprocity; The Jacobi symbol; Primality testing; The Fermat algorithm; The Solovay–Strassen algorithm; The Miller–Rabin algorithm; Factoring of integers; The Pollard algorithm for factoring; Square roots in a prime field. **Cryptography based on the integer ring:** Biprime cryptography; Implementing biprime cryptography; Protocol attacks on biprime cryptography; Direct attacks on biprime encryption; Factoring biprimes; The quadratic sieve; The number-field sieve; The Rabin cryptosystem; The rise and fall of knapsack cryptosystems.

**Cryptography based on the discrete logarithms:** Diffie–Hellman key exchange; Discrete logarithms; The Elgamal cryptosystem; Trapdoor one-way functions; The Massey–Omura cryptosystem; The Pohlig–Hellman algorithm; The Shanks algorithm; The Pollard algorithm for discrete logarithms; The method of index calculus; Complexity of the discrete-log problem.

**Information-theoretic methods in cryptography:** Probability space; Entropy; Perfect secrecy; The Shannon–McMillan theorem; Unicity distance; Entropy of natural language; Entropy expansion; Data compaction; The wiretap channel. **Block ciphers:** Block substitution; The Feistel network; The Data Encryption Standard; Using the Data Encryption Standard; Double and triple DES encryption; The Advanced Encryption Standard; Differential cryptanalysis; Linear cryptanalysis. **Stream ciphers:** State-dependent encryption; Additive stream ciphers; Linear shift-register sequences; The linear-complexity attack; Analysis of linear complexity Keystreams from nonlinear feedback; Keystreams from nonlinear combining; Keystreams from nonlinear functions; The correlation attack; Pseudorandom sequences; Nonlinear sets of sequences; Authentication and ownership protection; **Authentication:** Identification; Authentication signatures; Hash functions; The birthday attack; Iterated hash constructions; Formal hash functions; Practical hash functions

**Essential Reading:**


**Supplementary Reading:**


**Course Outcome:**

1. To build capability in analyzing and solving problems related secure communication.
2. To build capability to design algorithms for security in communication related applications.

**Course Coordinator:** Prof S Deshmukh
Pre-requisite: EC2502: Electromagnetic Theory

Design of short wire antenna, Calculation of field pattern for odd and even Half- wavelengths; Antenna Array, Linear array, Phased array; Array synthesis: Prediction of antenna array from radiation pattern, Detailed theoretical analysis of: Yagi-Uda array; Theory of: Horn antenna, Parabolic antenna, satellite antenna; Design of Microstrip antenna: Rectangular, square and circular patches; Transmission Line Model; Cavity Model; Design of Dielectric Resonator Antenna (Rectangular/Hemispherical) using different feeding techniques.

Essential Reading:

2. Aledo Petosa, *Dielectric Resonator Antenna Handbook*

Supplementary Reading:

2. J. D. Kraus, *Antenna Theory.*

Course Outcome:

1. Study of antenna parameters viz: Radiation resistance, Antenna resistance, Bandwidth, Beam width, Radiation pattern, Radiation intensity, Gain - Power gain Directive gain, Directivity, Antenna aperture, Efficiency, Effective aperture, effective length, Polarization
2. Design and analysis of Short wire antenna, Half-wave Dipole antenna, Yagi antenna etc
3. Study the working principles of Horn antenna and parabolic antenna
4. Design and analysis of Microstrip antenna along with its various parameters
5. Solving problems related to the above cases

Course Coordinator: Prof S K Behera

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Introduction to optical communication: Characteristics of optical transmission media, optical fibers- preparation and transmission characteristics, loss and dispersion mechanisms; Optical sources: principles of operation, modulation characteristics and driver circuits, LED, laser diodes, light source linearity, modal, and partition and reflection noise; Power Launching and Coupling: Source to fiber power launching, lensing schemes for coupling improvement, fiber to fiber joints, couplers, multiplexers and splices; Photo detectors: principles of operation, circuits and performance, preamplifiers and post-detection amplifiers; Optical Fiber systems: intensity modulation/direct detection system, link budget using direct detection, coherent system, wavelength converters, coherent and WDM systems, Photonic switching.

Essential Reading:

Supplementary Reading:
Course Outcomes:

1. Analyses the performance of both digital and analogue optical fiber systems,
2. Calculates the system bandwidth, noise, probability of error and maximum usable bit rate of a digital fiber system.
3. Calculates the system link loss, distortion and dynamic range of an RF photonic link.

Course Coordinator: Prof S K Das

EC 4507 INFORMATION THEORY AND CODING 3 Credits [3-0-0]


Essential Readings:

Supplementary Reading:

Course Outcome:

Course Coordinator: Prof S Deshmukh

Pre-requisite: EC 3502: Digital Communication, EC 3503: Probability and Random Variables

Introduction to Wireless Communication Systems- Evolution, Mobile Systems around the World, Example of the mobile radio systems, recent trends, 2G, 3G, 4G and emerging Cellular networks, brief overview of different wireless systems (WLAN, D2D, IOT, Satellite Communication, WPAN, WSN.) and comparative analysis, Technical design challenges in mobile communication systems. The Cellular Concept - Frequency reuse, Channel assignment, hand off process, Interference, Mobile Radio Propagation - Path loss, Radio wave propagation, Reflection, Diffraction, Scattering, link budget; Outdoor and indoor propagation models; Principle of multi path propagation - Impulse response model of channels, parameters for mobile multi path channels, concept of fading, Rayleigh and Ricean
fading; simulation of fading channels; **Modulations techniques for mobile communication:**- Pulse shaping, Linear and non-linear Modulation techniques, constant envelop modulation, QPSK, MSK, GMSK; **Spread spectrum modulation techniques**- Direct sequence and Frequency Hopping Spread Spectrum and their applications; **Equalization, Diversity and Channel coding:**- Fundamentals, General adaptive equalizer, Linear and non-linear equalizers, diversity techniques, RAKE receivers. Basic concept of coding; **Multiple access techniques:** - Introduction, FDMA, TDMA, CDMA, SDMA, capacity of cellular systems; **Introduction to Multicarrier systems, OFDM and wireless LAN, WiMAX, GSM, WCDMA, 3GPP LTE and other 4G standards.**

**Essential Reading**


**Supplementary Reading**


**Course Outcome:**

1. Distinguish and understand the major cellular communication standards (1G/2G/3G/4Gsystems) and wireless communications networks.
2. Understand the nature of the large scale, shadowing and small scale fading mobile radio channels and their implications for the design of communication systems.
3. Characterize and analyze various modulation and multi-carrier techniques used in Mobile communication.
4. Design of diversity techniques, equalization and coding schemes used in mobile communication

**Course Coordinator:** Prof. S. H. Hiremath

**EC 4509 MICROWAVE ENGINEERING 3 Credits [3-0-0]**


**Essential Readings:**
Supplementary Reading:

Course Outcome: Solving of numerical problems related to rectangular waveguide, Circular waveguide, rectangular Cavity resonator, Circular Cavity resonator etc. Study and analysis of E-plane Tee, H-plane Tee, Magic Tee, Phase Shifter, Attenuator, Directional Coupler, etc. Study of working principles of Reflex Klystron, Magnetron, and Travelling Wave Tubes. Study and analysis of measurement techniques for reflection coefficients, VSWR, frequency, and wavelength.

Course Coordinator: Prof S K Behera

EC 4510 SATELLITE COMMUNICATION 3 Credits [3-0-0]

Pre-requisite: EC 4509: Microwave Engineering

Introduction: Original Satellite Communications, History, Current State, Overview of Satellite System Engineering; Orbital Aspects of Satellite Communication: Orbital mechanism, look angle determination, orbit determination, orbit effects on Communication, System performance; Satellite Link Budget: Basic transmission theory, system noise and G/T ratio, down link design, satellite system using small earth station, up-link design; Modulation Multiplexing Techniques: Analog telephone transmission, Television transmission, Digital transmission, Digital TV and bandwidth Compression, time division multiplexing; Multiple Access Techniques: Frequency division multiple access, time division multiple access, code division multiple access, practical demand access systems, random access, multiple access with on-board processing; Satellite Earth Solution Techniques: Earth solution design, tracking, small earth station antennas, Equipment for the Earth station.

Essential Reading:

Supplementary Reading:

Course Outcome:

1. Study of Satellite system engineering, orbital mechanism, orbital effects on communication etc.
2. Design of satellite link budget.
3. Study and analysis of multiplexing, multiple access techniques.
4. Study and analysis of Earth station antenna and equipments.

Course Coordinator: Prof S K Behera

EC 4511 COMPUTER COMMUNICATION NETWORKS 3 Credits [3-0-0]

Course Outcomes:
1. Analyses the performance of both digital and analogue optical fiber systems,
2. Calculates the system bandwidth, noise, probability of error and maximum usable bit rate of a digital fiber system.
3. Calculates the system link loss, distortion and dynamic range of an RF photonic link.
4. Application knowledge of optical communication over networks

Course Coordinator: Prof S K Das

EC 4512 RADAR ENGINEERING 3 Credits [3-0-3]
Introduction: Radar basics, range equation, ambiguity function, receivers, transmitters, antenna, frequency bands, displays; Radar cross section (RCS) of targets, loss factors, jamming & clutter, accuracy of prediction, integration of radar pulses; Automatic target detection, tracking and sensor integration; Continuous wave (CW) radar; Coherent and non-coherent MTI radar, pulse Doppler radar, electronic scanning radar; Pulse compression, radar measurements, radar target detection and tracking, classification, recognition; Constant false alarm rate detectors; Statistical models for noise and target RCS, general characteristics of clutter and clutter modelling, clutter reduction; Radar imaging and signal processing.

Essential Readings:

Supplementary Readings:

Course Outcome:

Course Coordinator: Prof. L.P. Roy

EC 4513 OPTICAL AND SATELLITE COMMUNICATION 3 Credits [3-0-3]
Introduction to optical communication: Characteristics of optical transmission media, optical fibers- preparation and transmission characteristics, loss and dispersion mechanisms; Optical Components: principles of operation, modulation characteristics and driver circuits, LED, laser diodes, couplers, multiplexers and splices, light source linearity, modal, and partition and reflection noise; Photo detectors: principles of operation, circuits and performance, preamplifiers and post-detection amplifiers; Optical Fiber systems: intensity modulation/direct detection system, link budget using direct detection, coherent system, wavelength converters, coherent and WDM systems.
Introduction to Satellite Communication: Original / Traditional Satellite Communications, History, Current State, Overview of Satellite System Engineering; Orbital Aspects of Satellite Communication: Orbital mechanism, look angle determination, orbit determination, orbit effects on Communication, System performance; Satellite Link Budget: Basic transmission theory, system noise and G/T ratio, down link design, satellite system using small earth station, up-link design; Modulation Multiplexing Techniques: Analog telephone transmission, Television transmission, Digital transmission, Digital TV and bandwidth Compression, time division multiplexing.

Essential Reading:
Supplementary Reading:
Course Coordinator: Prof S K Das

EC 4514 TELECOMMUNICATION & SWITCHING NETWORKS 3 Credits [3-0-3]

**Text Books:**


**Reference Books:**


**Course Coordinator:** Prof S K Das

**EC 4602 DIGITAL IMAGE PROCESSING 3 Credits [3-0-0]**

**Pre-requisite: EC 3601: Digital Signal Processing**


**Essential Reading:**


Supplementary Readings:

Course Coordinator: Prof L P Roy

EC 4603 SOFT COMPUTING 3 Credits (3-0-0)


Essential Reading:

Supplementary Reading:

Course Outcome:
A graduate should be able to learn different Soft Computing techniques, e.g. neural networks, fuzzy logic and to apply these techniques in different real life problems.

Course Coordinator: Dr. Samit Ari

EC 4701 SOFT COMPUTING LABORATORY 1 Credit [0-0-2]
1. Implementation of a 2 input AND and OR logic function using perceptron. Start with different set of initial weights and show that there is more than one solution to the problem.

2. Develop an algorithm using Hebbian Learning rule to solve NAND and NOR problem. Assume the elements of initial weight matrix as random value and study the effect of different learning rates.

3. Solve the following Boolean function using Perceptron learning rule:
   \[ Y = \bar{x}_1 \bar{x}_2 x_3 + \bar{x}_1 x_2 \bar{x}_3 + x_1 \bar{x}_2 x_3 + x_1 x_2 x_3 \]

4. Consider the following function:
   \[ F(x) = x_1^2 + 2x_1x_2 - x_1^2x_2^2 \]
   Perform two iterations of Newton’s method from the initial guess \( x_0 = [1, -1]^T \).

5. Demonstrate that EX-OR and XNOR gate is a non-linearly separable problem. Design a MLP for the purpose and train it using BP algorithm. Assume the use of a logistic function for the nonlinearity.

6. Using a MLP with BP algorithm approximate the function \( y = 1 + \sin(2\pi x) \) for \(-1 \leq x \leq 1\). Draw the actual output and simulated output. Show the signal matching after 100/500/1000 iterations.

7. Implement a 2 input EX-OR gate using regularized RBF (use 4 centres). Plot the output surface for different input variables. Extend this for a 3 input RBF using 8 centers. Tabulate the input output pattern mapping for each case.

8. Using MLP/ RBF design a non-stationary time series prediction network to predict the output against time sample.

9. Let the meanings of the linguistic terms young and old be defined by the following membership function:
   \[ \mu_{\text{young}}(x) = \text{Gaussian}(x, 0, 20) = e^{-\left(\frac{x}{20}\right)^2}, \quad \mu_{\text{old}}(x) = \text{Gaussian}(x, 100, 30) = e^{-\left(\frac{x-100}{30}\right)^2}. \]
   Plot the MFs for the following linguistic values using MATLAB:
   - More or less old
   - Not young and not old
   - Young but not too young
   - Extremely old

10. Mini Project

**Course Outcome:**

To learn how to develop the different Soft Computing techniques, e.g. neural networks, fuzzy logic using MATLAB/C platform for real time application.

**Course Coordinator:** Dr. Samit Ari
1) Determination of different types of valve characteristics and calculation of the gain at various conditions.

2) To study pneumatic as well as hydraulic system using pneumatic trainer and hydraulic trainer.

3) To study and analyse the performance characteristics of an analog PID controller using simulated systems.

4) To study and analyse the time response of different processes with P, PI & PID controller using process control simulator.

5) Determination of the characteristics of Pneumatic/current (P/I) and current/pneumatic (I/P) converter.

6) Water level and Temperature control by PLC.

7) Performance analysis of on/off, P, PI and PID controllers using heat exchange

8) To design, implement and study the effects of different cascade compensation networks for a given system.

9) To study the time response of various simulated linear systems using linear system simulator.

10) To study the action of P, PI and PID controllers for a ‘Pressure Process’ using process control software.

11) Design of a pneumatic circuit using double acting cylinder and 5/2 air spring valve to open the main gate of a factory using P-simulator.

**Course Outcome:** Student can able to analyse the effect of tuning parameter in P, PI and PID controller in different types of Process. Characterize the different types of control valves and can simulate the different types of control strategies

**Course Coordinator:** Prof. U.C. Pati.

**EC 4703 COMMUNICATION NETWORKS LABORATORY**

1 Credit [0-0-2]

**Lists of Experiments:**

1. To demonstrate the basics of designing a network, taking into consideration the users, services, and locations of the hosts.

2. To simulate and study the basic features of an inter-domain routing protocol called Border Gateway Protocol (BGP).

3. To analyse the performance of RIP, a routing protocol built on a distance-vector routing algorithm.

4. To study the role of firewalls and virtual private networks (VPNs) in providing security to shared public networks such as the Internet.

5. The performance of local area networks connected by switches and hubs.

6. To study the effect of Web caching and data compression on the response time involved in accessing Web pages and on the load on the Web server.
7. Plot the characteristics curve between throughput and offered traffic for a slotted ALOHA system.

8. To simulate an Ethernet LAN using n nodes and set multiple traffic nodes plot contention window for different source destination pair.

9. To implement a mobile ad-hoc network (MANET) using the IEEE 802.11 standard.

10. To understand the different routing algorithms in wireless ad-hoc networks.

11. To simulate a three nodes point-to-point network with duplex link between them. Set the Queue size and vary the bandwidth to find the number of packets dropped.

12. Simulate the transmission of ping message over a network topology consisting of 6 nodes and find the number of packets dropped during the congestion.

13. To study how the bit error rate and data rate varies with the distance between Access point and the wireless node is varied.

14. To study an IoT based Smart Agricultural system

15. To Install and connect different IoT things to Node controller boards

**Software’s Required:** OPNET, NetSim, Iot Trainer Kit.

**Course Outcomes:**
1. The objective of the course is to ensure that students have the necessary networking skills to design, implement, and analyze communication networks.

2. Various standards and protocols will be covered.

3. Students will be able to design, implement, and analyze communication networks.

**Course Coordinator:** Prof S K Das

EC 4704 ADVANCED COMMUNICATION LAB 1 Credit [0-0-2]

**Pre-requisite:** EC- 3501 Principles of Communication Systems, EC- 3502: Digital Communication

**Hardware Experiments using Agilent signal generator and Vector Signal analyzer, Myreka kit, mini SDRs/USRP-GNU radio**

1. Study of various filters and their effect on the system, like spectrum shaping: CCDF and PAPR effects and BER effects, inter-symbol interference and eye diagram effects, vector (polar) diagram for Different digital standards from Agilent ESG.

2. Generate the TDMA and CDMA techniques that are used in GSM and CDMA system.

3. Generating and receiving an OFDM signal used for WLAN, WIMAX, LTE
   a) Measure SNR of the signal.
   b) Measure bandwidth of the signal
c) The measure dynamic range of the signal and PAPR using the time domain window.

d) What is the effect on the transceiver system?

e) Measure CCDF of the signal. Interpret the result of the CCDF?

4. **Designing and Test 3GPP W-CDMA Base Transceiver Stations (Including Femtocells)**

5. Analysis of the wireless Base band transmitter and receiver using Myreka kit.(Refer Myreka Manual).Study and understand:
   a) Super heterodyne transmitter and receiver
   b) The function of mixers
   c) The function of voltage controlled oscillator (VCO)

**Course Outcome**

1. On Completion of course able to analyze and implement Digital and Analog Communications transceiver system in various Hardware platforms.
2. Able to handle the various signal and spectrum measurement equipment’s that are used in Real time mobile technologies like WiMAX, WCDMA, LTE and soon
3. Design and implement various advanced communication systems in simulation environment.

**Course Coordinator:** Prof. S. H. Hiremath

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**EC 4705 SOFT COMPUTING LABORATORY 2 Credits [1-0-2]**


Introduction to Fuzzy systems, Membership function, Fuzzy relational operation, Fuzzy IF THEN rules, Sugeno and Mamdani type systems.

**Laboratory:**

11. Implementation of a 2 input AND and OR logic function using perceptron. Start with different set of initial weights and show that there is more than one solution to the problem.

12. Develop an algorithm using Hebbian Learning rule to solve NAND and NOR problem. Assume the elements of initial weight matrix as random value and study the effect of different learning rates.

13. Solve the following Boolean function using Perceptron learning rule:

\[
Y = \overline{x_1} \overline{x_2} x_3 + \overline{x_1} \overline{x_2} x_3 + x_1 \overline{x_2} x_3 + x_1 x_2 x_3
\]

14. Consider the following function:
Perform two iterations of Newton’s method from the initial guess \( x_0 = [1, -1]^T \).

15. Demonstrate that EX-OR and XNOR gate is a non-linearly separable problem. Design a MLP for the purpose and train it using BP algorithm. Assume the use of a logistic function for the nonlinearity.

16. Using a MLP with BP algorithm approximate the function \( y = 1 + \sin(2\pi x) \) for \(-1 \leq x \leq 1\). Draw the actual output and simulated output. Show the signal matching after 100/500/1000 iterations.

17. Implement a 2-input EX-OR gate using regularized RBF (use 4 centres). Plot the output surface for different input variables. Extend this for a 3 input RBF using 8 centers. Tabulate the input output pattern mapping for each case.

18. Using MLP/RBF design a non-stationary time series prediction network to predict the output against time sample.

19. Let the meanings of the linguistic terms young and old be defined by the following membership function:

\[
\mu_{\text{young}}(x) = \text{Gaussian}(x, 0, 20) = e^{-\frac{(x-0)^2}{20}}, \quad \mu_{\text{old}}(x) = \text{Gaussian}(x, 100, 30) = e^{-\frac{(x-100)^2}{30}}.
\]

Plot the MFs for the following linguistic values using MATLAB:

- More or less old
- Not young and not old
- Young but not too young
- Extremely old

20. Mini Project

Essential Reading:

Supplementary Reading:

Course Outcome:

Course Coordinator: Dr. Samit Ari

EC 4708 IoT Laboratory 1 Credit [0-0-2]

Course Outcome:
1. To design hardware and software on different platforms for devices that can be connected to internet.

Course Coordinator: Prof D.P.Acharya

EC 4709 VIRTUAL INSTRUMENTATION LABORATORY 1 Credit [0-0-2]

Course Outcome:
EC 4710 DIGITAL RADIO LABORATORY 1 Credit [0-0-2]

Pre-requisite: EC-3502: Digital Communication

Design of Communication system using COTs based Hardware like, NI-USRP(SDR), raspberry pie, Beagle bone and Ardrinuo microprocessor, TMS processor and FPGA implementation.

1. Design transmitters and receivers for AM, FM, Digital modulation schemes.
2. Design OFDM based transceiver system using USRP board
3. Send Video Data by a TCP/IP tunnel (with MAC Layer ENABLED) based on GNU Radio and USRP
4. Design of Real time spectrum monitoring system using SDR
5. Design of CoTs based intrusion detection system.
6. Design of mini Tactical radios for military applications
7. Design Machine 2 Machine(M2M) system for tactical, disaster management and medical application
8. Design system that converts a PC into CRO
9. Real time transmission data monitoring system
10. Design of adaptive wireless transceiver systems

Essential Reading:

Supplementary Reading:

Course Outcome:
1. Design and develop communication product using COTs based hardware like low cost processor like Beaglebone, Rasperry pi and FPGA and DSP single board Zync platforms.
2. To develop and model the real time software for multi-disciplinary communication applications.

Any other information:
The NI Optical Communication Lab: It comprising of the NI ELVIS Optical Communication Add-on Board extends NI ELVIS, NI ELVIS II, and NI ELVIS II+ with hardware and lab exercises to teach concepts related to Fiber Optic technology for Digital Communications

Course Coordinator: Prof S M Hiremath

EC 4711 OPTICAL FIBER COMMUNICATION LAB 1 Credit [0-0-2]

Lists of Experiments:
1. To understand the knowledge of fiber optical components, links, and systems.
2. To understand, describe, analyze, and compare the most important devices: light sources, fibers and detectors from both physical and system point of view.
3. To study the single/multimode fiber characteristics with testing and analysis
5. Design of Optical Transmitters:
   i) LED Modulation Response
   ii) Semiconductor Laser Modulation Response
   iii) Vertical-Cavity Surface-Emitting Laser - VCSEL
6. Design and study of Optical amplifiers:
   i) Raman amplifier
   ii) EDFA
   iii) SOA
7. To study Fiber optic voice link using amplitude modulation.
8. Measuring the BER of Optical Link in OFT
9. To study the PC to PC Communication using optical fiber
10. To design a WDM Fiber Optic Link
11. To Design a FSO Link under different atmospheric Conditions
12. To Design and analyze a Radio over Fiber (RoF) System
13. To study the LOS channel gain for the Indoor Optical Wireless Communication Channel (OWC)
14. Performance Comparison of High Speed Modulation Formats over Different Fiber Types for WDM Long-Haul Transmission Systems

**Software's Required:**
Light runner Kit, Optisystem, Benchmark OFT

**Course Coordinator:** Prof. S. K. Das

**Course Outcome:**
It gives overall idea through hands-on practice on image processing for enhancement and restoration of an image from interferences appeared in practice. Hence, the lab course is helpful for developing the ability of students to do project work on various image processing related topics like pattern recognition, pattern classification, computer vision, etc.. The course also suits well in industry and research where students will be in future.

**Course coordinator:** Prof. L.P. Roy
# EC 4713 RECONFIGURABLE SYSTEM DESIGN LABORATORY

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Contact Hours</th>
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<tbody>
<tr>
<td>EC 4713</td>
<td>RECONFIGURABLE SYSTEM DESIGN LABORATORY</td>
<td>1</td>
<td>[0-0-2]</td>
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</tbody>
</table>

Introduction to different reconfigurable platforms like CPLD, FPGA, PSoC, DSP etc.

Experiments using FPGA:
- Design a full adder using Dataflow modeling
- Design a full adder using half-adder
- Design a half adder
- Design a 4-bit adder cum subtractor using:
  - (a) 4:1 MUX using the following: (a) dataflow (b) using when else (c) structural modeling using 2:1 MUX
  - (d) behavioral modeling using (i) case statement (ii) if else statement (e) mixed style of modeling
  - (use structural, behavioral, dataflow)
- Design a Decoder (3 : 8) and Encoder (Gray to Binary)
- Design a BCD to 7-Segment Decoder
- Interface the 2-bit adder with 7-segment display
- Design 4-bit Even/Odd parity checker & generator
- Design of Flip-Flops:
- Design of counters, Design of Shift-Register:
  - (a) Serial-in serial-out
  - (b) Serial-in parallel-out
- Design the following using Generic:
  - (a) Generic Decoder
  - (b) Generic parity detector
  - Generic parity generator
- Design of controller for interfacing of PS2, LCD, VGA, UART, ADC and DAC with FPGA

Experiments using SOPC and PSoC

**Course Outcome:**
Handy knowledge of reconfigurable devices and their use in system building

**Course Coordinator:** Prof. D.P. Acharya

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# EC 4714 DSP PROCESSOR LABORATORY

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<tr>
<td>EC 4714</td>
<td>DSP PROCESSOR LABORATORY</td>
<td>1</td>
<td>[0-0-2]</td>
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</table>

**Course Outcome:** This course develops expertise and insight into the development of DSP processor solutions to practical engineering problems through hands-on experience. Structured exercises using DSP hardware are provided and used by the student to gain practical experience with basic DSP theory and operations.

**Course Coordinator:** Prof. A.K. Sahoo

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# EC 4715 VLSI DESIGN LABORATORY

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<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Contact Hours</th>
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<tbody>
<tr>
<td>EC 4715</td>
<td>VLSI DESIGN LABORATORY</td>
<td>1</td>
<td>[0-0-2]</td>
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</tbody>
</table>

Drawing schematic of PMOS & NMOS using S-Edit and Study their Characteristics, Layout of Basic circuit elements NMOS, PMOS using L-Edit, Layout & Circuit Simulation of CMOS Inverter, Impact of supply voltage and temperature, Simulation and layout of basic gates, Simulation and layout of basic gates, Simulation and layout of Flip-Flop, Back-End ASIC design flow using Cadence design tools.

**Course Outcome:** Knowledge of basic design of VLSI circuits SPICE, schematic and layout editors

**Course Coordinator:** Prof. A.K. Swain

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# EC 4716 ANALYTICAL AND BIOMEDICAL INSTRUMENTATION LABORATORY

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<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Contact Hours</th>
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<tbody>
<tr>
<td>EC 4716</td>
<td>ANALYTICAL AND BIOMEDICAL INSTRUMENTATION LABORATORY</td>
<td>1</td>
<td>[0-0-2]</td>
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</table>

1) Acquisition of Biopotentials using NI LabVIEW
2) Simulation of EEG using LabVIEW
3) Design of an Analog ECG Signal Generator using LabVIEW
4) Design of a Biosignal Logger
5) Design of a Heart Rate Analyzer.
6) Spectrum Analysis of ECG and PCG signals
7) Extraction and analysis of Brainwaves from EEG signal
8) Spectrum analysis of Noisy and pure Biosignal
9) Biofeedback system on EMG
10) Acquisition of PCG signal

**Course Outcome:** Students can be able to acquire biopotentials, analyse important biopotentials like ECG, EEG and EMG, and design instrumentation system for analysis of physiological variables.

**Course coordinator:** Prof. B. Mukherjee

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**EC 4717 MOBILE COMMUNICATION SIMULATION 1 Credit [0-0-2]**

List of Experiments:

1. Simulate a wired communication system in which information signal is sent out over an AWGN channel. Assuming BPSK modulation plot BER vrs SNR curve in Matlab. Compare the simulate and theoretical curve.

2. Simulate a wired communication system in which information signal is sent out over an AWGN channel. Assuming QPSK and 8PSK modulation plot BER vrs SNR curve in Matlab. Compare the BER performance of different digital modulation schemes. Compare the simulate and theoretical curves.

3. Simulate a following long term propagation models (with shadowing and clutter factor) for wireless communication: a). Friis free space model; b). Two ray model; c). Okumura Hata model. Observe these models for change in frequency and distance.

4. Simulate power delay profile for a wireless communication system. Compute mean access delay and relate coherence bandwidth for different power delay profiles.

5. Simulate a wireless communication system in which information signal is sent out over an AWGN channel with flat fading. Assuming BPSK modulation, plot BER vrs SNR curve in Matlab. Compare performance with wired channel. Also compare the simulate and theoretical curve.

6. Simulate a wireless communication system in which information signal is sent out over an AWGN channel with flat fading. Assuming QPSK, 8PSK modulation, plot BER vrs SNR curve in Matlab. Compare performance with wired channel. Also compare the simulate and theoretical curve.

**Essential Reading**

**Supplementary Reading**
Course Outcomes

Course Coordinator: Prof S Deshmukh

Course Content:

1. Design and simulation of Rectangular Microstrip Patch Antenna with a particular operating frequency, Dielectric constant and substrate thickness.
2. Design and simulation of nearly square patch Antenna with a particular operating frequency, Dielectric constant and substrate thickness.
3. Design and simulation of Dual band Rectangular patch antenna using inset feeding technology.
4. Design and simulation of Dual band nearly square patch antenna using inset feeding technology.
5. Design and simulation of Rectangular Microstrip Patch Antenna using probe feeding with slot for bandwidth enhancement.
6. Design and simulation of nearly square patch Antenna with a particular operating frequency, Dielectric constant and substrate thickness for circular polarization.
7. Design and simulation of Rectangular Microstrip Patch Antenna using CPW feeding with slot for bandwidth enhancement.
9. Design and simulation of Circular Microstrip Patch Antenna with a particular operating frequency, Dielectric constant and substrate thickness.
10. Design and simulation of Dielectric Resonator Antenna with a particular operating frequency, Dielectric constant and substrate thickness.
11. Design and Simulation of Fractal Antennas for wireless applications.
12. Design and simulation of MPA for Ultra-Wide Band (UWB) applications.
13. Design and Simulation of MPA using MATLAB.
14. Design and optimization of MPA using PSO.
15. Design and simulation of Metamaterial based antenna.

Essential Reading:

1. C.A. Balanis, Antenna Theory: Analysis & Design, 2nd Edition
2. Aledo Petosa, Dielectric Resonator Antenna Handbook
3. User manuals of HFSS V.15
Supplementary Reading:


Course Outcome:

1. Design and simulation of simple microstrip patch antenna structure using HFSS.
2. Design and simulation of Fractal antenna structure using HFSS.
3. Design and simulation of Dielectric Resonator Antenna with a particular operating frequency, Dielectric constant and substrate thickness.
4. Design and simulation of MPA for Ultra-Wide Band (UWB) applications
5. Design and optimization of MPA using PSO
6. Design and simulation of Metamaterial based antenna

Course Coordinator: Prof S K Behera

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<th>EC 4719</th>
<th>PROCESS CONTROL</th>
<th>1 Credit</th>
<th>[0-0-2]</th>
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<tr>
<td>LABORATORY</td>
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To study the characteristics of P/I & I/P converter; Determination of the different types of valve characteristics & calculate the gain at various condition; Study and synthesis of Hydraulic & Pneumatic systems using Trainers; Experiments on Air velocity sensor and its associate signal conditioner circuit; Performance analysis on ON-OFF/P/PI/PD/PID controllers on Co-Current and Counter Current Heat Exchanger Process; Phase-Plane analysis on Relay Control system; Study of Linear System Simulator; Study of Compensatin Design Network.

Course Outcome: Student can able to analyse the effect of tuning parameter in P, PI and PID controller in different types of Process. Characterize the different types of control values and can simulate the different types of control strategies.

Course Coordinator: Prof. T.K.Dan

<table>
<thead>
<tr>
<th>EC 4720</th>
<th>MICROWAVE ENGINEERING LABORATORY</th>
<th>1 Credit</th>
<th>[0-0-2]</th>
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<tbody>
<tr>
<td></td>
<td>Using Gunn Oscillator Based Microwave Test bench: Study of Gunn Oscillator; Study of Frequency, Guide wavelength; Measurement of VSWR, Reflection coefficient, Impedance measurement; Study of Directional coupler; Study of Variable Attenuator</td>
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<td></td>
<td>Using Microwave Test bench for Antenna Measurement: To plot the polar pattern &amp; gain characteristics of the following Antennas; Pyramidal Horn; Pickup Horn; Slotted Horn; Slotted Wave Guide Antenna; Dielectric Antenna; Sectorial Horn (E &amp; H-Plane); Parabolic Dish;</td>
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<tr>
<td></td>
<td>Using HFSS v.14: Simulation of Microstrip patch Antenna to study the following parameters; Impedance Plot; Radiation pattern; Bandwidth; S-parameters(S11, S12, S22 etc).; Gain; Efficiency</td>
<td></td>
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</tbody>
</table>

Essential Reading:

1. D M Pozar, Microwave Engineering, John Wiley & Sons, 2004
2. User manual of HFSS version 15

Supplementary Reading:

**Course Outcome:**

1. Study the characteristics of Gunn Oscillator and Reflex Klystron
2. Measurements of VSWR, reflection coefficient, frequency, wavelength and impedance using microwave test bench
3. Study of characteristics of Directional Coupler and magic tee
4. Measurement of radiation pattern of horn antenna and parabolic antenna
5. Design and simulation of simple microstrip patch antenna structure using CST Microwave studio and HFSS

**Course Coordinator:** Prof S K Behera

**EC 4721 PCB DESIGN AND FABRICATION**

1 Credit [0-0-2]

**Course Outcome:** To design and fabricate PCB for different applications.

**Course Coordinator:** Prof D.P.Acharya

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**DEPARTMENT OF ELECTRICAL ENGINEERING**

**EE 1000 Basic Electrical Engineering**

4 credits [3-1-0]

**Introduction:** Sources of energy, steam, hydro and nuclear power generation, general structure of electrical power systems.

**DC Networks:** Kirchoff’s laws, node voltage and mesh current methods, delta-star and star-delta conversions, superposition principle, Thevenin’s and Norton’s theorems, Maximum Power Transfer Theorem.

**Single phase AC circuits:** Single phase emf generation, average and effective values of sinusoids, solution of R, L, C series circuits, j operators, solution of parallel and series-parallel circuits, series -parallel resonance.

**Three-phase AC circuits:** Three phase emf generation, delta and star connections, line and phase quantities, solution of the three phase circuits with balanced voltage and balanced load conditions, phasor diagram, measurement of power in three phase circuits, three phase four wire circuits.
Magnetic circuits: Review of fundamental laws of electromagnetic induction, transformer and rotational emfs, Solution of magnetic circuits.

DC machine: Construction, emf and torque equations, speed control of DC motors.

Single Phase Transformer: Construction, emf equation, phasor diagrams at no load and full load, equivalent circuit, regulation and efficiency.

Induction Motor: Introduction to three-phase induction motor, construction, principle of rotating magnetic field, starting; single phase induction motor, principle of operation.

Measuring Instruments: Introduction to basic instruments, voltmeter, ammeter and wattmeter, principle of analog and digital measurements.

Essential Reading:


Supplementary Reading:


EE 2401 Signals & Networks 4 credits [3-1-0]

Course Contents:


Essential reading:


Supplementary reading:

Course Contents:

Magnetic circuits: Magnetic materials and their properties, Flux linkage, inductance and energy, magnetically induced emf, ac operation of magnetic circuits, electromagnetic force and torque, hysteresis and eddy current losses. Transformers: Construction and practical considerations, No load conditions, ideal transformer, practical transformer and equivalent circuit, losses, testing, the Per Unit system, efficiency, voltage regulation, excitation phenomenon, autotransformers, three phase transformer, parallel operation of transformers, three winding transformers, Scott connection, Tap changing transformers

DC Machines: Armature winding and commutator, EMF and Torque, circuit model, armature reaction, compensating winding, commutation, methods of excitation. DC generator: operation characteristics, self-excitation, characteristics, parallel operation. DC motors: starting, speed control, braking, efficiency, testing and dynamics. Applications of DC machines.

Essential Reading:


Supplementary Reading:


Course Contents:

Scope and applications of analog electronic circuits, Amplifier models: Voltage amplifier, Current amplifier, transconductance amplifier and transresistance amplifier. Biasing schemes for BJT and FET amplifiers, bias stability, various configurations(such as CE/CS, CB/CG, CC/CD) and their features, small signal analysis, low frequency transistor models, estimation of voltage gain, input resistance, output resistance etc., design procedure for particular specifications, low frequency analysis of multistage amplifiers. High frequency transistor models, frequency response of single stage and multistage amplifiers, various classes of operation (Class A, B, AB, C etc.), their power efficiency and linearity issues. Oscillators: Review of the basic concept, Barkhausen criterion,RC oscillators (phase shift, Wien bridge etc.), LC oscillators (Hartley, Collpit, Clapp etc.) . Differential amplifier: Basic structure and principle of operation, calculation of differential gain, common mode gain, CMRR and PSRR. OP-AMP design: design of differential amplifier for a given specification, design of gain stages and output stages, compensation. OPAMP applications: review of inverting and non-inverting amplifiers, integrator and differentiator, summing amplifier, precision rectifier, non-sinusoidal oscillators, Schmitt trigger and its applications. Active filters: Low pass, high pass, bandpass and bandstop, design guidelines. Digital-to-analog converters (DAC): Weighted resistor, R-2R ladder, resistor string etc. Analog-to-digital converters (ADC): Single slope, dual slope, successive approximation, etc.
**Essential reading:**


**EE 2002 Electrical Machines-II 4 credits [3-1-0]**

**Course Contents:**


Synchronous machines: Basic model, circuit model, synchronous reactance, Potier method, Armature reaction, synchronizing to infinite bus bar, operating characteristics, efficiency, power flow equations, Two-reaction model, Synchronizing power and torque, Slip test, Parallel operation, hunting phenomenon and starting methods.


Introduction to Brushless Permanent Magnet motors, Stepper motor, Switched reluctance motor,

**Essential Reading:**

1. A. E. Fitzagerald, C. M. Kingsley (Jr) and S. D. Umans, Electric Machinery, TMH, 2003.

**Supplementary Reading:**

Course Contents:

**Power Semiconductor Devices:** power diodes, power transistors, SCRs, TRIAC, GTO, power MOSFETs, IGBTs - Principles of operation, characteristics, ratings, protection and gate drive circuits, dv / dt and di / dt protection, Series and parallel operation of Thyristors.

**Controlled rectifiers:** Single phase and Three-phase, Effect of Source Inductance, Power factor improvement, Dual converter.

**DC-DC converters:** Buck, Boost, Buck-Boost converters with circuit configuration and analysis. Introduction to Zero Voltage Switching and Zero Current Switching.

**DC-AC converters:** Single phase and Three-phase; Voltage Source (VSI) and Current Source Inverter (CSI), frequency and voltage control; Pulse Width Modulation Techniques (PWM). Introduction to Multilevel Inverter.

**AC-AC converter:** Single and Three phase controllers, phase control, PWM AC voltage controller, Principle of ON-OFF control and Cyclo-converters.

**Essential reading:**


**Supplementary reading:**


Course Contents:

**Measurement of Electrical Quantities:** Standards of Measurement & Errors, Voltmeter, Ammeter, Multimeter, Wattmeter and Energy meter. **Measurement of Electrical Elements:** Measurement of low, medium and high resistances, insulation resistance measurement AC bridges for inductance and capacitance measurement. **Instrument Transformers:** Current and Potential transformers, ratio and phase angle errors. **Electronic Measurements:** Electronic voltmeter, multi-meter, wattmeter & energy meter. Time, Frequency and phase angle measurements using CRO; Spectrum & Wave analyzer. ; Digital counter, frequency meter, voltmeter, multi-meter and storage oscilloscope. ; **Instrumentation:** Transducers, classification & selection of transducers,
strain gauges, inductive & capacitive transducers, piezoelectric and Hall-effect transducers, thermistors, thermocouples, photo-diodes & photo-transistors, encoder type digital transducers, Signal conditioning and telemetry, basic concepts of smart sensors and applications. Data Acquisition Systems.

**Essential reading:**


**Supplementary reading:**


**EE 2402 Digital Electronics 3 credits [3-0-0]**

**Course Contents:**


**Essential Reading:**


**Supplementary Reading:**


EE 3401 Microprocessors & Embedded Systems 4 credits [3-1-0]

Course Contents:
Overview of Embedded System and Design; The 8085 Microprocessor: Architecture & Programming; Microprocessor Peripheral Interface Controller & I/O interfaces: Memory Interface, Parallel Interfaces for Signal Acquisition, User Interface (Keyboard & Displays), Serial Communication Protocol & Interface, Programmable Interval Timer, Programmable Interrupt Controller, Direct Memory Access; The 8086 Microprocessor: Architecture & Programming; 8051 Microcontroller: Architecture & Programming; Microcontroller Peripheral Interfacing: Real-time Operating System, Parallel Interface for Signal Acquisition, User Interface (Keyboard & Displays), Design with Low Pin Count, Serial Communication Protocol & Interface, External Memory Interface; Application of Embedded Systems and Simulation.

Essential reading:
1. Datasheets of various chips (Intel 8085, 8086, 8051: AT89S8252, Peripheral Interface Chips, ADCs, DACs etc.)

Supplementary reading:
1. Datasheets of various accessory IC components

EE 3301 Principles of Control Systems Engineering 3 credits [3-0-0]

Course Contents:
Frequency domain specifications, MP and WP for a second order system; The Nyquist criterion and stability:

Introduction, The Principle of argument the Nyquist path, Nyquist criterion and the GH Plot, The application of the Nyquist criterion, The effects of additional poles and zeros of G(s) H(s) on the shape of the Nyquist locus, Relative stability, gain margin, Phase margin, conditionally stable systems. The Root Locus Technique: Introduction to Root Locus, construction of the root loci, some other properties of the root locus, root locus of conditional stable systems; Compensator Design: Lag/Lead/Lag-Lead Compensator Design using Root Locus & Bode Plot Methods; State variable analysis: Introduction, Concept of state, state variable and state model, State equations of continuous data control system, Derivation of state Model from transfer functions and Vice versa. Diagonalisation, Solution of state equation.

Essential Reading:

Supplementary Reading:
3. R.C. Dorf and R.H.Bishop, Modern Control System, Pearson, 2017

Course Contents:

An introduction to signals and systems, and representation of signals in time domain, Linear, time-invariant systems, impulse response and convolution sum, Fourier transform, Sampling and Reconstruction of continuous time signals, Characterization and properties of discrete time signals and systems, Computation of the discrete time Fourier transform and its properties, Computation of the discrete Fourier transform and its properties, Fast Fourier transform algorithms, The Z-transform and its properties, The inverse z-transform, System function and system stability, Transform analysis of linear time invariant systems, Implementation of structures for discrete time systems, Digital filter design techniques, Design of FIR & IIR filters, Applications of DSP.

Essential Reading:

Supplementary Readings:
1. **Power System Network**: Basic structure of power system, Transmission voltages, Bundled conductors, Choice of economics voltages.

2. **Line Parameters**: Resistance, Inductance and Capacitance Calculations; Single Phase and Three Phase Lines, Effect of Earth on transmission line Capacitance.

3. **Performance of Transmission Lines**: Representation of lines; Short, Medium and Long length transmission line, Equivalent π and T circuits, Regulation and Efficiency, Evaluation of ABCD parameters, Line voltage regulation and compensation.

4. **Overhead Line Insulators**: Insulator materials, Types of insulators, voltage distribution over insulator string, Improvement of string efficiency.

5. **Mechanical Design of Overhead Lines**: Line supports, Span conductor configuration, spacing and clearances, sag and tension calculations, Effect of Wind and Ice loading.

6. **Corona**: The phenomenon of corona, Corona loss, Factors and conditions affecting corona loss, Corona in bundled conductor lines. Interference between Power and Communication Lines: Electromagnetic Induction, Electro Static induction, Reduction of interference.

7. **Underground Cables**: Classification of cables, Insulation Resistance, Potential gradient, Capacitance of single core and three core cables.

8. **Power System Transients**: Travelling waves on transmission lines, Wave Equations, Attenuation of travelling waves.

9. **Distribution Systems**: Comparison of various distribution systems and General aspects, Kelvin’s Law, AC Distribution; Single phase and Three phase, Techniques of Voltage Control and Power Factor Improvement.

**Essential Reading:**

**Supplementary Reading:**

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**Course Contents:**
Factors affecting selection of drives, speed-torque characteristics of motors and loads, condition of steady-state stability, transient stability: equal area criterion, dynamics of motor load combination, DC shunt motor and series motor braking methods and speed-torque characteristics in four quadrants, Induction motor: steady-state performance analysis, braking methods, four quadrant speed-torque characteristics, dc and ac dynamic braking, Methods of starting, energy relations during starting and braking, Transients in dc and ac drives; Motor and converter performance parameters, 1-phase
full- and semi- converter fed dc shunt and dc series motor, Mathematical analysis of 1-phase converter fed dc motors, 1-phase Dual converter: waveforms, operations with and without circulating current, 3-phase full converter, semi converter and dual converter fed dc drives, Power factor considerations of semi- and full converters, Power factor improvement of phase controlled converters, Sequence control of converters, Chopper controlled dc drives; Static speed control of induction motor: stator voltage control, Static control of rotor resistance, Static slip power recovery scheme, VSI and cyclo-converter fed drives, V/f control, constant torque and constant power operations, closed loop V/f control, CSI fed drives; Induction motor behaviour with non-sinusoidal supply and unbalanced supply, PWM inverters and reduction of harmonics, Synchronous motor drives: true and self-synchronous modes, hunting; Brushless dc motor drive, Reluctance motor, SRM, stepper motors; Illumination, electrical heating, furnaces, arc welding, industrial application of motors in steel mills, textile mills, cement mill and paper mills; Electric traction services, nature of traction load, main line and sub-urban train configuration, traction mechanics, traction drives, braking, power factor and harmonics, traction motor.

Essential reading:

Supplementary reading:

EE 3100 Power System Operation and Control 3 credits [3-0-0]

Course Contents:


4. **Optimal Dispatch of Generation:** Operating cost of a thermal plant, Economic Dispatch problem, Unconstrained and constrained optimization technique, Economic dispatch neglecting losses, Kron’s loss formula, Economic dispatch including losses.

5. **Automatic Generation and Voltage Control:** Load Frequency control, concept of control area, Proportional plus Integral control, Two-Area load frequency control,
Automatic voltage control, Regulator, Exciter modelling, Generator modelling and static performance of AVR loop.

**Essential Reading:**

**Supplementary Reading:**

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**EE 3302 Advance Control Systems**

Course Contents:

**State Space Analysis:** State space modeling of different dynamical systems, Conversion of transfer functions to various canonical representation, Linearization of non-linear system, Solving the state space equations, Eigenvalues and Eigenvectors, Different methods of calculations the state transition matrix, Controllability and Observability, state feedback control, pole placement through state feedback, State feedback with integral control, Observer design; **Digital Control:** Introduction to discrete time systems, Sample and Hold, Z-transform, State variable analysis of digital control systems ; **Optimal Control:** Principal of optimality, Continuous time LQ control, Infinite-Horizon Control, Linear Quadratic Regulator; **Lyapunov stability analysis:** Basic concepts, stability theorems, Lyapunov functions for LTI systems; **Nonlinear Control System:** Characteristics of nonlinear systems, common nonlinearities, phase plane, describing function;

**Essential Reading:**

**Supplementary Reading:**

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**EE 3402 Communication Systems**

Course Contents:

Representation of signals and systems in a communication system: Discrete and continuous spectra of signals, concepts of modulation and frequency translation, lowpass and bandpass signals and channels, concept of complex envelope, Hilbert transform and phase shifting; Continuous wave (CW) modulation: AM, DSB/SC, SSB, VSB, methods of generation; Demodulation techniques of CW modulation: coherent and non-coherent; Nonlinear modulation techniques: FM and PM, narrowband FM, wideband FM, methods of generation; FM spectrum; Demodulation techniques for FM; Frequency Division Multiplexing (FDM); Radio transmitters and receivers; Sampling a signal by periodic pulse stream: spectra of ideally sampled signal, Nyquist sampling theorem, flat-top sampling, sampling of bandpass signals, examples of sampling circuits; PAM, PWM, PPM spectra, generation and demodulation schemes; Time-division multiplexing; Performance of analog modulation schemes in AWGN : CNR,
post-demodulation SNR and figure of merit for AM, DSB/SC, SSB, FM, threshold effect in FM, pre-emphasis and de-emphasis in FM, FMFB. Noise in receivers; Noise figures; Radio link design

Essential Reading:

Supplementary Reading:

EE 3004  
**Electro Magnetic Field Theory**  
3 credits [3-0-0]

Course Contents:

Essential reading:

Supplementary reading:

EE 3404  
**Soft Computing Techniques**  
3 credits [3-0-0]

Course Contents:
1. **Optimization**: (a) Convex Optimization - Unconstrained optimization by Steepest Descent method, Newton’s method, Damped Newton method; Constrained optimization – KKT conditions, Lagrangian method. (b) Non-convex Optimization - Genetic algorithm, Particle Swarm Optimization
2. **Artificial Neural Network**: Characteristics and Benefits of Artificial Neural Network; Basic models of Artificial Neurons; Basic Activation Functions; Network Architectures; Adaptive Linear Model: Widro-Hopf solution; Classification by single perceptron; Training single perceptron by Gauss-Newton method. Multilayer Perceptron: Back-propagation Learning Algorithm; Radial Basis Function (RBF) Neural Network, training of RBF Neural Network using stochastic gradient approach.

3. **Principal Component Analysis (PCA)**: Dimension Reduction using PCA, Pre-processing input patterns of Neural Network using PCA.


**Essential Reading:**

**Supplementary Reading:**

**Course Contents:**

Basic terminologies, 1st order and second order instruments with step, ramp and sinusoidal input/output characteristics, Strain gauge, derivation of gauge factor, strain gauge rosette, unbalanced Wheatstone bridge, Link type load cell, beam type load cell, ring type load cell and their sensitivities, Frequency response of link type load cell, Torque cell and its data transmission (slip ring and radio telemetry), LVDT, phase compensation, phase sensitive demodulation, thermistor and its linearization, RTD, its construction, three wire and four wire method Muller bridge, Thermocouple, their relative comparison, cold junction compensation using AD590, grounded thermocouple, potentiometer as displacement sensor, Capacitance as displacement and level transducer, push pull arrangement, Pressure transducer [Bourdon gauge, diaphragm gauge (metal and semiconductor) etc], all vacuum gauges, photo electric transducer and its application, Liquid in glass thermometer, pressure spring thermometer, venturimeter, Orifice meter, pitot tube, Rotameter, Weir, electromagnetic flowmeter, Hot wire anemometer, its phase compensation and expression of volumetric flow rate or velocity in each case, Variable reluctance displacement sensor, tachogenerator, turbine flowmeter. Measurement of viscosity, conductivity and pH of a liquid. Flapper nozzle system and Control Valves.
Essential Reading:


Supplementary Readings:


EE 3406 Probability and Random Processes 3 credits
[3-0-0]

Course Contents:

Introduction to Probability: Sets and set operations, probability space, conditional probability and Bayes theorem, combinatorial probability and sampling models.

Random Variables: Discrete random variables, probability mass function, probability distribution function, example random variables and distributions; continuous random variables, probability density function, probability distribution function, example distributions; joint distributions, functions of one and two random variables, moments of random variables; conditional distribution, densities and moments, characteristic functions, Markov, Chebychev and Chernoff bounds, detection and estimation.

Sequence of Random Variables and Convergence: Random sequences, Almost sure (a.s.) convergence and strong law of large numbers; convergence in mean square sense with examples from parameter estimation; convergence in probability with examples; convergence in distribution; central limit theorem.

Random Processes: Random processes, stationary processes, mean and covariance functions, ergodicity, linear filtering of random processes, power spectral density, examples of random processes: white noise process and white noise sequence, Gaussian process, Poisson process, Markov process.

Essential Reading:


Supplementary Reading:


State Variable Analysis: State descriptions of digital processors, conversion of state variable models to transfer functions, conversion of transfer functions to canonical state variable models, first comparison form, second companion form, Jordan Canonical form, state description of sampled continuous time plants, solution of state difference equations, closed form solution, state transition matrix, Caley-Hamilton Technique, concept of controllability and observability, loss of controllability and observability due to sampling.

Digital Controller Design: Design of state observers, dead beat control by state feedback and dead beat observers, Lyapunov stability analysis, Linear Quadratic Optimal Control, Nonlinear Control systems

Essential Reading:


EE 3102 Utilization of Electrical Energy 3 credits [3-0-0]


Essential Reading:


Supplementary Reading:

EE 4301 Robust and optimal Control 3 credits
[3-0-0]

Course Contents:
Space, Range space, Null space, Convex set, Norm of vector, signal and matrix, $H_2$ and $H_\infty$ norm, Hamiltonian matrix, Riccati equation. Concept of robustness in SISO and MIMO systems, Small-gain theorem, Robust controller synthesis using $H_\infty$ norm minimization, $\mu$-synthesis, LQR problem, Guaranteed stability margins of LQR, Linear estimation, Separation Theory, Standard $H_2$ problem, Stability Margins of $H_2$ Controllers.

Essential Readings:

Supplementary Reading:

EE 4101 Power System Protection 3 credits
[3-0-0]

Course Contents:
1. Overview of Power System Protection: General architecture of protection system, Evolution of relays, Attributes of a protection system, Current and potential transformer for relays, Zones of protections, Concept of primary and back-up protection.

2. Overcurrent Protection: Construction, Operating Principle and Characteristics of Instantaneous overcurrent relay, Definite Time overcurrent relay, Inverse Time overcurrent relay, Inverse definite minimum time overcurrent relay; Coordination of overcurrent relays for radial lines, Overcurrent protection of three-phase feeder; Construction, Operating Principle and Characteristics of Directional overcurrent relay, Directional overcurrent protection of a three-phase feeders; Drawbacks of overcurrent protection.

3. Distance Protection: Universal Torque Equation, Construction, Operating Principle and Characteristics of Simple Impedance relay, Reactance relay, and Mho relay, performance of different impedance relays during normal loading condition, power swing and effect of arc resistance, Directional properties of
various impedance relays, Impact of infeed effect; Distance protection of a three-phase line, Three-stepped distance protection.

4. **Differential Protection**: Dot convention, Simple differential protection – behavior during normal load, external fault and internal fault; Actual behavior of a simple differential protection scheme and Percentage Differential relay.

5. **Busbar Protection**: Differential protection of busbars, actual behavior of a protective current transformer – effect of CT saturation, High Impedance busbar protection.

6. **Transformer Protection**: Over-current protection, Percentage differential protection of transformer, Inrush phenomenon, percentage differential relay with harmonic restraint; High resistance ground fault protection of a $Y-\Delta$ transformer; Inter-turn faults in transformer, Buchholz relay; Protection against over-fluxing.


**Essential Reading:**

**Supplementary Reading:**

**EE 4401**          **Digital Image Processing**          **3 credits**

[3-0-0]

**Digital image fundamentals and Transforms**: Elements of visual perception, image sampling and quantization, basic relationship between pixels, basic geometric transformations, 2D Fourier Transform, DFT, FFT, Separable Image Transforms, Walsh – Hadamard, Discrete Cosine Transform, Haar, Slant – Karhunen – Loeve Transforms.

**Image Enhancement**: intensity transformations, contrast stretching, histogram equalization, correlation and convolution; spatial domain filters: smoothing filters, sharpening filters; Frequency domain filters: smoothing filters, sharpening filters, homomorphic filter.
Image Restoration: Model of Image Degradation/restoration process, Image deformation and geometric transformations, Noise models, inverse filtering, least mean square filtering, constrained least mean square filtering, Blind image restoration, Pseudo inverse, Singular value decomposition.


Wavelets and Multiresolution Processing: Image pyramids, subband coding, Harr transform; multi resolution expression, Wavelet transforms.

Morphological Image Processing: Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, convex hull, thinning, thickening, skeletons, pruning, Geodesic dilation, Geodesic erosion, reconstruction by dilation and erosion.

Image Segmentation: Boundary detection based methods, region-based methods, template matching, Hough transform, Mean shift, active contours, Use of motion in segmentation

Essential Reading:


Suggested Reading:


EE 4103 High Voltage Engineering & HVDC Transmission 3 credits [3-0-0]

Course Contents:


Essential Reading:

Supplementary Reading:

EE 4201 Modeling and Control of Power Electronics Systems 3 credits [3-0-0]

Course Contents:

Modeling: steady state analysis of dc/dc and dc/ac converters, dynamic analysis of converters, state space average modeling, PWM switch modeling and discrete time modeling, modeling of dc/dc converters operating in discontinuous conduction mode, dc/dc and dc/ac converters transfer functions.

Overview of dc/dc power electronics circuits: Voltage-mode control, current-mode control, complexity of operation, complex behavior in power electronics computer and laboratory techniques for studying nonlinear behavior in switching power converters.


Nonlinear control of dc/dc Converters: Practical design of conventional hysteresis modulation-based sliding mode controllers for power converters, General approach of deriving fixed-frequency PWM-based sliding mode controller for power converters in
discontinuous conduction mode, Design and implementation of fixed-frequency PWM-based sliding mode controller for power converters, Model predictive control of converters and inverters systems

**Control of power inverters:** Power Quality Control --- Current $H^\infty$ repetitive control, voltage and current $h^\infty$ repetitive control, Voltage $H^\infty$ repetitive control with a frequency-adaptive mechanism, Voltage $H^\infty$ repetitive control with a frequency-adaptive mechanism, Control of inverter output impedance, Power Flow Control---Current proportional–integral control, Current proportional–resonant control, Robust droop control with improved voltage quality, synchronization----Conventional synchronization techniques, Sinusoid-locked loops.

**Essential Reading:**
1. John G. Kassakian, Martin F. Schlecht, George C. Verghese, Principles of Power Electronics: Addison-Wesley Series

**EE 4403**  
**VLSI Technology**  
3 credits  
[3-0-0]

**Course Contents:**


**Essential Reading:**

**Suggested Reading:**

**EE 4105**  
**Smart Grid**  
3 credits [3-0-0]

**Course Contents:**

**Basics of Power Systems:** Load and Generation, Power Flow Analysis, Economic Dispatch and Unit Commitment ProblemsSmart Grid: Definition, Applications, Government and Industry, Standardization,

**Smart Grid Communications:** Two-way Digital Communications Paradigm, Network Architectures, IP-based Systems, Power Line Communications, Advanced Metering Infrastructure

Renewable Generation and Resources: Carbon Footprint, Wind and Solar, Microgrid Architecture, Tackling Intermittency, Stochastic Models and Forecasting, Distributed Storage and Reserves


Prerequisites: This course is intended for graduate students but it is also open to senior undergraduate students. There is no official pre-requisite at the time of enrolment. However, basic knowledge of power systems, basic knowledge of computer and communications networks, and some back ground in probability and random variables, linear algebra, and convex optimization will be helpful.

Essential Reading:


EE 4405 Digital Communication 3 credits [3-0-0]

Course Contents:

Concepts of information and entropy; Source coding: Coding theorem, fixed length codes; Variable length codes; Quantization of signals; Waveform coding techniques: PCM, DPCM, ADPCM, DM, ADM; Baseband transmission: intersymbol interference, noise, eye pattern, BER analysis, Optimum filtering, equalization techniques; Clock recovery; Line coding techniques: Binary and multilevel line codes; Digital modulation schemes: Binary modulation schemes- ASK, PSK, FSK, DPSK; M-ary modulation schemes: QPSK, MPSK, MSK; QAM: generation and demodulation schemes, carrier recovery techniques, BER analysis of digital modulation systems; Shannon’s channel capacity theorem and spectral efficiency of digital modulation schemes.

Essential Reading:

EE 4407 MEMS and Nano Electronics 3 credits [3-0-0]

Course Contents:


Shrink-down approaches of Transistors: Introduction, CMOS Scaling, The nanoscale MOSFET, FinFETs, Vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.), Resonant Tunneling Transistors, Single electron transistors, new storage, optoelectronic, and spintronic devices. Atoms-up approaches: Molecular electronics involving single molecules as electronic devices, transport in molecular structures, molecular systems as alternatives to conventional electronics, molecular interconnects; Carbon nanotube electronics, band structure& transport, devices, applications.

Suggested Reading:


EE 4002 Special Machines 3 credits [3-0-0]

Course Contents:


Essential reading:


Supplementary reading:


EE 4302 Robotics and Computer Vision 3 credits [3-0-0]

Course Contents:

Introduction:

Automation and Robotics, Basic Structure of Robots, Robot Anatomy, Classification of Robots, Fundamentals about Robot Technology, Factors related to use Robot Performance, Basic Robot Configurations and their Relative Merits and Demerits, the Wrist & Gripper Subassemblies.

Kinematics of Robot Manipulator:


Trajectory Planning:

Trajectory Interpolators, Basic Structure of Trajectory, Interpolators, Cubic Joint Trajectories. General Design Consideration on Trajectories: - 4-3-4 & 3-5-3 Trajectories

Dynamics of Robotic Manipulators:


Control design for Robotic System:
Control Loops of Robotic Systems, trajectory, velocity and force control, Computed Torque control, Linear and Nonlinear controller design of robot.

**Robot Sensing & Vision:**


**Application of Robotics:**

Applications of robotics in active perception, medical robotics, autonomous vehicles, and other areas.

**Essential Reading:**


**Supplementary Reading:**


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**EE 4402 Wireless and cellular communication 3 credits [3-0-0]**

**Prerequisites**

Communication Systems, Digital Communications, Digital Signal Processing

**Course Contents:**


**Essential reading:**

Supplementary reading:

EE 4102                              Renewable energy systems                              3 credits
[3-1-0]

Course Contents:

- **Sources of Energy:**
  Traditional energy systems, Sources, Features and characteristics, Applications, Renewable energy sources and features, Distributed energy systems and dispersed generation

- **Solar Energy:**
  Solar thermal systems: Solar processes and spectral composition of solar radiation; Radiation flux at the Earth’s surface, Solar collectors, types and performance characteristics, Applications.

- **Wind Energy:**
  Wind energy conversion, efficiency limit for wind energy conversion, types of converters, aerodynamics of wind rotors, power ~ speed and torque ~ speed characteristics of wind turbines, wind turbine control systems, conversion to electrical power, characteristics of wind power plant, Applications.

- **Other sources of Energy:**
  Micro-hydel: Operating principle, Components of a micro-hydel power plant, Types and characteristics of turbines, Selection and modification.
  Geothermal Energy: Geothermal resources, Exploration of geothermal energy, Geothermal power generation, Applications.

- **Hybrid Systems:** Need for hybrid systems, Range and type of Hybrid systems: Diesel-PV, Wind-PV, Micro-hydel-PV, and System with battery backup.

Essential reading:

Supplementary reading:

EE 4404                           Information Theory and Coding                         3 credits
[3-0-0]

Course Contents:
Entropy and Mutual Information: Entropy, Joint Entropy and Conditional Entropy, Relative Entropy and Mutual Information, Chain Rules, Data-Processing Inequality, Fano’s Inequality; Typical Sequences and Asymptotic Equipartition Property: Asymptotic Equipartition Property Theorem, Consequences of the AEP: Data Compression, High-Probability Sets and the Typical Set; Source Coding and Data Compression: Kraft Inequality, Huffman Codes, Optimality of Huffman Codes; Channel Capacity: Symmetric Channels, Properties of Channel Capacity, Jointly Typical Sequences, Channel Coding Theorem, Fano’s Inequality and the Converse to the Coding Theorem; Differential Entropy and Gaussian Channel: Differential Entropy, AEP for Continuous Random Variables, Properties of Differential Entropy, Relative Entropy, and Mutual Information, Coding Theorem for Gaussian Channels; Linear Binary Block Codes: Generator and Parity-Check Matrices, Repetition and Single-Parity-Check Codes, Binary Hamming Codes, Error Detection with Linear Block Codes, Weight Distribution and Minimum Hamming Distance of a Linear Block Code, Hard-decision and Soft-decision Decoding of Linear Block Codes, Cyclic Codes, Parameters of BCH and RS Codes, Interleaved and Concatenated Codes; Convolutional Codes: Encoder Realizations and Classifications, Minimal Encoders, Trellis representation, MLSD and the Viterbi Algorithm, Bit-wise MAP Decoding and the BCJR Algorithm.

Essential reading:

1. Elements of Information Theory by Thomas Cover, Joy Thomas
2. Channel Codes: Classical and Modern by William Ryan, Shu Lin

Supplementary reading:

1. Information Theory and Reliable Communication by Robert Gallager

EE 4602 Optimization Technique 3 credits [3-0-0]

Course Contents:


Essential reading:


Supplementary reading:

### EE 4302 System Identification and Adaptive Control 3 credits [3-0-0]

**Course Contents:**


Convergence and Consistency conditions on the date set, Information content in the Data set consistency and Identifiability.

Recursive Estimation Methods, Recursive Least-Squares Algorithm, Recursive Instrumental Variable Method, Recursive Maximum Likelihood.

Nonlinear System Identification Techniques


Deterministic Self-tuning Regulator (SIR), Pole-placement design, Indirect SIR.

Continuous time self-tunes, Direct STRs, Disturbances with known characteristics.

Stochastic and predictive STR. Design of Minimum Variance Controls, Stochastic STRs, Linear Quadratic STR, Analysis of Indirect Discrete time STRs, Analysis of Direct Discrete time STRs.


**Essential reading:**


**Supplementary reading:**


### EE4202 Switched -Mode DC –DC Converters 3 credits [3-0-0]

**Course Contents:**

Essential reading:

Supplementary reading:

EE 4406  Advanced Topics in Signal Processing  3 credits  [3-0-0]

Course Contents:


Essential reading:
2. R. M. Young, An Introduction to Nonharmonic Fourier Series, academic press, 2001 OR Recent edition

Supplementary reading:
1. O. Christensen, An Introduction to Frames and Riesz Bases, Springer Science, 2016 or Recent Edition

EE 4501  Speech Processing  3 credits  [3-0-0]

Course Contents:


Suggested Reading:
EE 4601  An Introduction to Machine Learning  3 credits [3-0-0]

Course Contents:

Introductory Topics, Linear Regression and Feature Selection, Linear Classification, Support Vector Machines, Artificial Neural Networks, Bayesian Learning, Decision Trees, Evaluation Measures, Hypothesis Testing, Ensemble Methods, Clustering, Graphical Models, Learning Theory and Expectation Maximization.

Essential Reading:


EE 4503  Pattern Recognition  3 credits [3-0-0]

Course Contents:


Essential Reading:

1. R.O. Duda, P E Hart, D G Stork; Pattern Classification; John Wiley and Sons (Student Edition); 2003
2. R. Singhal; Pattern Recognition: Techniques and Applications; Oxford University Press, 2006.

Supplementary Reading:

EE 4502 Statistical Signal Processing 3 credits [3-0-0]

Course Contents:


Essential reading:


Supplementary reading:


EE 4004 Bio Medical Instrumentation 3 credits [3-0-0]

Course Contents:


Essential Reading:


*Biomedical Signal Analysis by RM Rangayan Microcomputer Interfacing* by J.J. CarrLabWindows CVI manuals (National Instruments)

Supplementary Reading:


EE 3011                                               Electrical Machines                                               3 Credit [3-0-0]

Course Content:

1. **Transformer**: Single Phase Transformer: Review of EMF equation and equivalent circuit, phasor diagrams on lo load and full load, per-unit representation of transformer parameters, voltage regulation, losses and efficiency, OC and SC test, all day efficiency. Three Phase Transformer: Construction of various types, operating characteristics of star–star, star–delta, delta – star, delta – delta, open – delta connections, vector groups.

2. **D.C. Motor**: Review of EMF and torque equations, classification, losses and efficiency, Swinburne’s test & Hopkinson’s test, torque /speed characteristics and speed control of shunt and series motors.


4. **Synchronous Machines**: Constructional features, synchronous generators and motors, equivalent circuit and phasor diagram, power and torque characteristics, voltage regulation of non-salient pole alternators by synchronous impedance method, V-curve and inverted-V curve, starting of synchronous motors.

Essential Reading:


Supplementary Reading:


EE 3112                                                POWER SYSTEM                                               3 Credit [3-0-0]

Course Contents:

1. **Power System Network**: Basic structure of power system, Introduction to power generation, transmission and distribution system, Power network in India.

2. **Line Parameters**: Transmission line resistance, Inductance, Flux Linkage of an isolated current-carrying conductor, Inductance of a single-phase two-wire line, Flux linkage of one conductor in a group, Inductance of composite conductor lines, Inductance of three phase lines, Bundled conductors; Capacitance of a two-wire line, capacitance of a three-phase line with equilateral spacing, Capacitance of a three-phase line with unsymmetrical spacing, Effect of earth on transmission line capacitance.

3. **Representation of Power system Components**: Single-phase solution of balanced three-phase network, Single line diagram of power system, Per-Unit system, classical model of synchronous machine.

4. **Performance of Transmission Line**: Evaluation of ABCD parameters for short transmission line, medium transmission line and long transmission line, Nominal T and π representation, Ferranti effect, Line voltage regulation and voltage control.


7. **Power System Protection**: General architecture of protection system, Evolution of relays, Attributes of a protection system, Current and potential transformer for relays, Zones of protections, Concept of primary and back-up protection, Introduction to overcurrent protection, distance protection, differential protection; Circuit Breaker operation and types.

**Essential Reading:**

**Supplementary Reading:**

**EE 3412 Digital Electronics and Microprocessor 3 Credit [3-0-0]**

Course Contents:


**Essential Reading:**

**Supplementary Reading:**
3. Liu and Gibson; Microprocessor Systems: The 8086/8088 Family: Architecture, Programming and design, PHI.
1. Testing of single phase energy meter at different power factors.
2. Extension of range of a PMMC meter and its conversion from voltmeter to ammeter & vice versa.
4. Study of power factor at different loads i.e. resistive, inductive & capacitive.
5. Measurement of single phase power by three ammeter and three voltmeter method.
6. Verification of Thevenin and Superposition theorem.
7. Measurement of three phase power by two wattmeter method.
8. To conduct load test on a separately excited dc generator and obtain its internal and external characteristics.
9. Measurement of power using CT and PT.

EE2701 Signals and Networks Lab 1 credits [0-0-2]

Course Contents:

Introduction: Learning about the laboratory tools: Hardware like Signal generator, Oscilloscope, Circuit components, and special equipments & Software like MATLAB & Simulink, LABVIEW;

Simulation: Time & frequency domain representation of signal (any signal viz. sound, speech etc.); Signal parameter measurement; Explore noise & signal to noise characteristics; Understanding sampling of signal and sampling theorem, Understanding analog & digital frequency and their properties; Understanding Fourier transform & Fourier series of signal; Understanding aliasing of signal during sampling; Frequency response of LTI systems (Filter); Series & Parallel resonance circuit simulation and their parameter measurement;

Hardware Realization: Understanding network theorems (Thevenin, Norton, Superposition, and Maximum power transfer) through proto-boarded circuits with dependent sources (DC & AC); Sinusoidal Steady State Response of RC, RL, and RLC circuits; Transient Response of RC, RL, and RLC circuits; OPAMP circuits for filters; Two port network parameter determination of RLC circuit (T or π);

Essential reading:


Supplementary reading:


EE2702 Electrical Machine Lab-I 2 credits [0-0-3]

Course Contents

1. Open circuit and short circuit tests on a single phase transformer and determination of equivalent circuit parameters.
2. Load test on single phase transformer to determine efficiency and voltage regulation.
4. Speed control of a dc motor by varying armature circuit and field circuit resistance.
5. Speed control of Dc series motor.
6. Swinburne’s test of dc machines
7. Load test on dc shunt motor.
8. Measurement of DC machine parameters – armature winding resistance, field winding resistances, moment of inertia, coefficient of friction
10. Load test on three phase induction motor.

EE2706  
Analog Electronics Lab  
1 credits [0-0-2]

Course Contents
1. (i) Junction Diode Characteristics and Zener Diode Characteristics (ii) Half Wave and Full Wave Rectifier design using diode.
2. Study of Clipper and Clamper circuits using diode.
3. Transistor Characteristics under CE mode and determination of α and β.
5. Study of single stage RC coupled transistor Amplifier and measurement of various parameters like impedance, power and phase.
6. D.C Characterization of JFET and MOSFET.
7. Linear applications of Operational Amplifier.
8. Measurement of Offset parameters of OPAMP.
9. Study of some nonlinear OPAMP circuits.
10. Study of FET amplifiers.

Suggested Reading:

EE2704  
Electrical Measurement and Instrumentation Lab  
1 credit [0-0-2]

Course Contents
Calibration of single phase digital energy meter at different loads; Measurement of capacitance and inductance using ac bridges. Synchro, Temperature measurement using RTD Virtual Instrumentation: Simulation: Measurement of single phase power, biomedical instrumentation, obtaining the quadrature component of a given signal, Hardware: Measurement of displacement using LVDT, Measurement of current, voltage and power from a solar panel, Measurement of angular speed and angular position for a dc motor. Measurement of magnetic field and current using Hall effect sensor

Essential Reading:

Supplementary Reading:

EE 3701  
Electrical Machines Lab. – II  
2 Credits [0-0-3]

Course Contents:
Determination of equivalent circuit parameters of 3-phase induction motor using no load and blocked rotor test, Load test on three phase induction motor, Speed control of slip ring induction motor by varying rotor resistance and to obtain speed torque characteristics at different rotor resistance, Load test on three phase induction generator, To perform the no load test and blocked rotor test on a single phase induction motor (Capacitor type), Determination of regulation of three phase alternator by synchronous impedance method and zero power factor method, Parallel operation of three phase alternator with infinite bus, To obtain V curves and inverted V curves of synchronous motor, Determination of XD and XQ of a salient pole
synchronous machine (slip test), To obtain the performance characteristics of a synchronous motor

Essential reading:

Supplementary reading:

EE 3703  Power Electronics Lab.  2 credits [0-0-3]

Course Contents:

1. To study the static characteristics of SCR, MOSFET, IGBT.
2. To study the Pulse converter and 1-Ø half controlled bridge converter with R & R-L load.
3. To study the 1-Ø full controlled bridge converter with R & R-L load.
4. To study the 3-Ø half controlled bridge converter with R & R-L load.
5. To study the open loop and close loop response of DC-DC Buck converter.
6. To study the open loop and close loop response of DC-DC Boost converter.
7. To study the open loop and close loop response of DC-DC Buck-Boost converter.
8. To study the single phase IGBT based PWM inverter.
9. To study a Voltage commutated chopper circuit with it's time-ratio control.
10. To study the speed control of 3-Ø induction motor using IGBT based PWM inverter.
11. To study the closed loop speed control of a DC-motor by tachogenerator feedback method.
12. To study the operation of 3-Ø voltage source inverter.

EE 3705  Electronics Circuit Lab.  2 credits [0-0-3]

Course Contents:

1. Characterization of Simple and Cascade Current Mirror circuits (BJT and MOSFET)
2. Design of differential amplifier with resistive load (BJT) and active load (MOSFET)
3. Design of R-C and L-C oscillators (phase shift/Wein Bridge/Colpitt/Hartley)
4. Design of a second order active filter (low pass/high pass)
5. Study and Design of Power Amplifiers (Push Pull/Class A).
6. Study of basic logic gates and universal logic gates; Realization of logic circuits using universal logic gates; To construct and verify the operation of single digit and multi digit half adder, Full adder / subtractor using logic gates and IC 7483.
7. Comparison of Sequential and Combinational Logic Circuits; Study of Digital to Analog converter by weighted resistance method. Design and verification of A/D converter; Study of Seven Segment Display Technique using IC 7447/ 7446.
8. To study the characteristics and operation of a programmable Shift Register using IC 7495; Verification of UP/ DOWN count using IC 74193.
9. Study of Ring and Decade Johnson Ring counters using ICs and Flip-Flops.

10. Using HDL /Verilog

   (i) Static and Dynamic Characteristic of NAND and Schmitt-NAND gate (both TTL and MOS); Synthesis of a logic function by NAND gates only. (minimized and two level).

   (ii) Measurement of delay of the logic sp synthesized; Design a clock by using NAND gates and R-C network as well as crystal

   (iii) Study the functionality of Multiplexer and using it design and implement a logic circuit

   (iv) Study the principle of a Demultiplexer and implement multi-output logic circuit

   (v) Experiment on Serial-in, Parallel-in Serial-out right shift register with preset and clear.

   (vi) Generate maximally long linear sequence using this shift register and other necessary logic gates.

   (vii) Study the dynamic characteristic of a J-K flip-flop and hence find out maximum operational frequency

   (viii) Design a ripple modulo counter and set-rest feedback method. Verify the states of count.

   (ix) Determine each stage delay and total delay. Determine the maximum clock frequency that it is able to count

   (x) Design a sequential circuit and implement it by J-K flip-flops and other related logic gates.

EE 3702 Control Systems Lab. 2 credits [0-0-3]

Course Contents:

1. Study the Transient and frequency response of a second order network.
2. Study of a DC motor driven closed loop position control system
3. Study of a Position Control System using Synchro
4. Obtain speed-torque characteristics of an AC Servomotor
5. Determination of the transfer function of a system (network) using a transfer function analyser.
6. Identification of a DC Motor transfer function, position and speed control of a DC motor using PD and PID Controller via Ziegler Nichol’s tuning method
7. Study the discrete-time version of the PID controller, and to implement classical tuning rules for the digital control system
8. Modelling and control of oven for temperature control
9. Microprocessor based PID control of a DC servo motor
10. Study of PID controller performance on stabilisation of an Inverted Pendulum
Course Contents:

Introduction: Datasheet Study, Design, Simulation & Hardware Realization; Different Signal Generation of Variable Specification using Microprocessor Circuit/ microcontroller; Multi-tasking Real-Time Operating System Development: Performance Test between Polling and Interrupt based Approaches; Interfacing with ADCs and DACs; User Interface Circuit Development (Keyboards, LCD & LED Display); Digital FIR filter Realization; Electrical/Electronic Device Interface and Control.

Essential Reading:

1. Datasheets of various chips (Intel 8085, 8086, 8051: AT89S8252, Peripheral Interface Chips, ADCs, DACs etc.)

Supplementary Reading:

1. Datasheets of various accessory IC components

Course Contents:

Magnetic circuit design, thermal design aspects of electrical machines, design of transformers, design of rotating machines, armature winding design.

Essential Reading:


Course Contents

High Voltage Laboratory

1. Determine the impulse ratio of a porcelain pin insulator.
2. Measure capacitance and \tan\delta of 3 Phase underground cable and 3 Phase Transformer.
3. Determination of string efficiency of a string of suspension insulator.
4. Testing of insulation strength of transformer oil and atmospheric air.

Power System Laboratory

5. a. Study of operating characteristics of electromechanical over current relay and plotting a graph between trip time and plug setting multiplier (PSM).
b. Study of operating characteristics of numeric over current relay and plotting a graph between relay operating time and fault current.

6. a. Testing of electromechanical over voltage relay and plot the graph between trip time and plug setting multiplier (PSM).
   b. Testing of electromechanical under voltage relay and plot the graph between operating time and percentage plug setting voltage.

7. a. Study the voltage profile of a long transmission line and effect of shunt reactor compensation.
   b. Measurement of ABCD constant, characteristic impedance and propagation constant of a Transmission Line.

8. Study the scheme for power factor improvement.

9. Study the double Bus-bar coupling and Bus-bar transfer scheme without interruption of the power supply to the consumer. Also study the switching sequence for disconnector/isolator and power circuit breaker

EE4703 Communication Systems Lab 1 credit [0-0-2]

Course Contents:

Amplitude modulation; DSB AM Modulator, Calculation of the modulation index, Observation of the linearity curve of modulator, DSB AM reception using Envelop Decoder, Operation of AM with Suppressed carrier; Study of SSB, Signal Generator, SSB Signal Demodulation, Calculate the sensitivity and Selectivity of a AM Receiver; Frequency modulation; Modulation Characteristic of Varactor Modulator, measurement of frequency; Deviation and calculation of modulation index, Demodulation characteristic of the FM Demodulator (Foster- Seeley Demodulator), FM demodulation using Ratio Demodulator, Phase locked loop Detector and Quadrature detector, FM super Heterodyne Receiver; Phase Modulation: Phase Modulation, Phase Demodulation; Analog Signal Sampling and its reconstruction; Natural Sampling and its reconstruction, Sample and Hold and its reconstruction, Flat loop Sampling and its reconstruction, Effect of different sampling frequencies, Effect of varying the sampling frequency duty cycle; Study of TDM Pulse Amplitude Modulation / Demodulation with Transmitter lock and Channel identification information linked directly to the receiver; Sampling and Pulse Code Modulation.

EE 4705 Control & Electrical System Design Lab 1 credit [0-0-2]

Course Contents:

Designing an electronic scale for measuring weight: Objective: Explore the specifications of weight scale; Design an electronic weight-scale system; Focus area: A/D converter dynamic range, peak to peak noise resolution. Designing a DC/DC converter: Objective: Explore the specifications of DC/DC converter, Design the controller to regulate the output. Focus area: Steady state modelling for power stage design, dynamic modelling for controller Design, controller design. Load frequency control for power system: Objective: To study and design load frequency controller. Focus area: Modelling from specifications, performance determination, controller design. Designing of controllers for robotic manipulator. Objective: To study and design robotic manipulator; Focus area: Modelling, various controller design.

EE 4707 Power Electronics Simulation Lab 1 credit [0-0-2]
1. Simulation of 1-phase half-wave uncontrolled and controlled converter with R, RL and RLE loads
2. Simulation of 1-phase full-wave uncontrolled bridge rectifier with R, RL and RLE loads
3. Simulation of 1-phase semi-controlled converter with R, RL and RLE loads
4. Simulation of 1-phase full-controlled converter with R, RL and RLE loads
5. Simulation of 3-phase semi-controlled converter with R, RL and RLE loads
6. Simulation of 3-phase full-controlled converter with R, RL and RLE loads
7. Simulation of buck converter
8. Simulation of boost converter
9. Simulation of buck-boost converter
10. Simulation of 1-phase AC voltage controller
11. Simulation of 3-phase bridge inverter
12. Modelling and simulation of DC motor

EE 4702                             Digital Signal Processing Lab     1 credit [0-0-2]

Course Contents:
Write a program for linear convolution of two sequences; Write a program for circular convolution; Write a program to perform linear convolution using circular convolution; Write a program to perform N-point DFT. Also perform the IDFT on the result obtained to verify the result; Write a program to perform circular correlation using: Direct method b) circular convolution using rotation method; Write a program to perform circular convolution and correlation using DFT; Write a program to perform linear convolution using (a) overlap save method (b) overlap add method; Write a program to perform FFT on a sequence using the following methods. (a) Decimation in time (b) Decimation in frequency; Write a program to perform IDFT on a transformed sequence using DFT; Write a program to design an FIR filter using windowing technique; Write a program to design an IIR filter using (a) impulse invariant method (b) bilinear transformation method.

EE 4704                             Soft computing Lab                  1 credits [0-0-1]

Course Contents

1. Introduction to MATLAB programming
2. Convex optimization by Steepest Descend method
3. Convex optimization by Newton’s Method
4. Non-convex optimization by Genetic Algorithm
5. Non-convex optimization by Particle Swarm Optimization
6. Training of simple perceptron by Widro-Hopf solution and Gauss-Newton method
7. Linear classification by simple perceptron
8. Training Multi-layer perceptron by Back-propagation algorithm
9. Principal Component Analysis and its Application
10. Fuzzy Modelling and Inference by Fuzzy Rule Base
EE 4706  
Power System Simulation Lab  
1 credits [0-0-2]

Course Contents:
1. Introduction to MATLAB Programming
2. Gauss-Seidel Load Flow Analysis
3. Fast Decoupled Load Flow Analysis
4. Symmetrical Fault Analysis
5. Sequence components and Asymmetrical Fault Analysis
6. Transient Stability Analysis
7. Determination of Optimal Scheduling of Generation

EE 4708  
Renewable Energy Lab  
1 credit [0-0-2]

Course Contents:
2. Simulation of SEIG and study of its voltage build-up process.
3. Simulation of a solar panel at various level of insolation and temperature and plot the VI characteristics.
4. Study of the self-excitation characteristics of an induction generator
5. Determination of the equivalent circuit parameters and the performance characteristics of a grid-connected induction generator
6. Study of static characteristics of wind turbine (WT) by emulating the wind turbine behaviour by means of a separately-excited DC motor
7. Measurement of V-I characteristics of a solar panel at various levels of insolation, and the identification of the equivalent circuit parameters
9. Workout power flow calculations of stand-alone PV system of DC and AC load with battery.
10. Study of the charging and discharging characteristics of the battery.

DEPARTMENT OF FOOD PROCESSING ENGINEERING

DETAILED COURSE SYLLABUS
B.Tech. (Food Process Engineering)

FP 2101  
Food Chemistry  
3 credits [3-0-0]

Objective: To learn fundamentals of food chemistry.

Syllabus:
Food chemistry and its role in food processing. Water: Importance of water in foods, Structure of water & ice, Concept of bound and free water and their implications. Proteins: Nomenclature, classification, structure, chemistry and properties of amino acids, peptides, proteins; Essential and
non-essential amino acids, Qualitative and quantitative analysis of amino acids and proteins, Changes during food processing. Carbohydrates: Nomenclature and classification, structure, physical and chemical properties of polysaccharides and their functions; Qualitative and quantitative analysis of carbohydrates: changes in carbohydrates during food processing. Lipids: Structure, classification, physical and chemical properties, utilization of fats and oils, margarine, shortenings, salad and cooking oils, importance of fats and oils in diet, introduction to hydrogenation and its importance. Browning reactions: Enzymatic and non-enzymatic browning, advantages and disadvantages, factors affecting their reaction and control. Vitamins and minerals: Types of vitamins and minerals, chemistry and functions, sources and deficiency diseases. Plant pigment: Importance, structure and properties of plant pigments, chemical changes of pigments during food processing. Flavour and aroma of foods: Importance, structure and properties of flavouring and aromatic components of foods.

**Essential Reading:**
1. Food Chemistry by Meyer
2. Food Chemistry by Fennema
3. Basic Food Chemistry by Lee

**Supplementary Reading:**
1. Food Chemistry by Belitz
2. Principles of Biochemistry by Lehninger

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**FP 2201 Food Processing Operations - I 3 credits [3-0-0]**

**Objective:** To learn various heat transfer related unit operations in food processing.

**Syllabus:**

**Essential Reading:**
1. Unit Operations in Food Processing by R.L. Earle, Published by NZIFST (Inc.)
2. Fundamentals of Food Process Engineering by R.T. Toledo, Published by Springer
3. Engineering Heat transfer by Karlekar and Dashmond

**Supplementary Reading:**
2. Unit operations in Food Engineering by A. Ibarz and Gustavo V Barbosa-Canovas
3. Drying and Dehydration of Foods. Loesecke, Allied Scientific Publishers
4. Food Process Engineering and Technology by ZekiBerk, Published by ELSEVIER
5. Engineering Heat transfer by Gupta and Prakash,
6. Handbook of Industrial Drying by A.S. Mujumdar. Published by Taylor and Francis

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**FP 2102 Principles of Food Technology 3 credits [3-0-0]**

**Objectives:** To learn various fundamental principles of food engineering

**Syllabus:**

Essential Reading:
1. Unit Operations in Agricultural Processing by Sahay and Singh
2. Fundamentals of Food Process Engineering by R.T. Toledo, Published by Springer
3. Food Process Engineering and Technology by Zeki Berk, Published by ELSEVIER

Supplementary Reading:
1. Food Processing Handbook, by J.G. Brennan, Published by WILEY-VCH Verlag GmbH & Co. KGaA
2. Food Process Engineering and Technology by Zeki Berk, Published by ELSEVIER
3. Engineering Heat transfer by Gupta and Prakash,
4. Handbook of Industrial Drying by A.S. Mujumdar. Published by Taylor and Francis

FP 2101 Food Properties Laboratory 2 credits [0-0-3]

Objectives: To learn various engineering properties of biological materials.

Syllabus:
Determination of physical dimension and average particle size of food grains, Determination of bulk density, true density and porosity of grains, Determination of volume and specific gravity of fruits De-termination of roundness and roundness ratio of biological materials, Determination of sphericity of biological materials, Determination of angle of repose of food grain samples, Determination of frictional properties of biological material, Determination of aerodynamic properties of biomaterial, To study the separating behaviour of a grain sample in a vertical wind tunnel (aspirator column), Determination of moisture content of sample by direct and in-direct methods, Measurement of (grain, fruit) hardness (Moh’s hardness test), compressive strength, Determine flow parameters of Newtonian, Non Newtonian food products by: Capillary tube, viscometer, Hakke’s viscometer, Rotational viscometer and Falling ball viscometer. Viscosity measurement using (RVA, Brookfield viscometer), Texture Profile Analysis of different food samples, Optical properties measurement using hunter Lab/CIE colour system, Optical properties measurement using Spectrophotometer, Optical properties measurement using Tintometer, To determine specific heat of some food grains, To find the thermal conductivity of different grains. To find the electrical impedance of the grain

Essential Reading:
1. Physical Properties of Plant and Animal Materials, 2nd Ed, Gordon & Breach Science Publisher by N.N. Mohsenin
2. Practical Manual on Post Harvest Technology, Published by Banaras Hindu University, Varanasi, by R. C. Pradhan and P. P. Said.
3. Thermal properties of food and agricultural materials, Gordon & Breach Science Publisher by N.N. Mohsenin

Supplementary Reading:
4. Electromagnetic radiation properties of food and agricultural materials, Gordon & Breach Science Publisher by N.N. Mohsenin
**FP 2103 Food Microbiology and Safety 3 credits [3-0-0]**

**Objectives:** To get in-depth knowledge of food borne microorganisms, their growth, and detection, control and food preservation

**Syllabus:**
Introduction: scope of food microbiology; Microorganisms important in food industry; Types of micro-organisms, their importance in foods, classification of food borne bacteria, their morphology and distinguishing features with examples; Growth of microorganisms in foods; Intrinsic (pH, moisture content, redox potential, nutrient content, antimicrobial constituents and biological structures) and extrinsic factors (temp., RH, presence and concentration of gases) governing growth of microorganisms in food; Food spoilage: Chemical changes caused by microorganisms in foods (breakdown of proteins, carbohydrates, fats and other constituents during spoilage), specific microorganisms causing spoilage of milk and milk products, meat, fish, egg, cereals, fruits, vegetables and their processed products, quality defects in canned foods, sugar and confectionary products; Food fermentations: General description of fermenters, parts and their functions, different types of fermentations (static, submerged, agitated, batch, continuous). Microbial culture selection by screening methods and strain improvement. Starter cultures - definition, types, Fermentation - definition, types (acid, alcohol). Fermented foods - types, methods of manufacture for vinegar, ethyl alcohol, cheese, yoghurt, baker's yeast and traditional Indian foods; Microbial Foodborne Diseases: Introduction, types of microbial foodborne diseases (foodborne intoxications and foodborne infections and foodborne toxicoinfections), symptoms and prevention of some commonly occurring food borne diseases; Food Preservation: Principles of preservation, methods of food preservation – high temperature, low temperature, drying, radiation, chemical preservatives, bio-preservatives, hurdle technology, active packaging, novel processing technologies. Special topics in safety: Microbial attachment and Biofilm formation, microbial metabolism of food components, food preservatives of microbial origin, bacteriocins and nanotechnology, food spoilage by microbial enzymes, opportunistic bacterial pathogens, molds and mycotoxins, viruses, parasites, fish and shell fish toxins.

**Essential Reading:**
1. Food Microbiology, TMH, New Delhi by W C Frazier & D C Westhoff
2. Modern Food Microbiology, CBS Publication, New Delhi by J M Jay
3. Essentials of Food Microbiology, Arnold, London by John Garbutt

**Supplementary Reading:**
5. Microbiology of Safe Food, Blackwell Science, Oxford by S J Forsythe
7. Microbiology of foods by J C Ayres, J O Mundt, W E Sandine, W H Freeman

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**FP 2402 Food Grains Processing 3 credits [3-0-0]**

**Objective:** To learn various processes and methods of Food Grains

**Syllabus:**
Production, Economics, and processing scenario of Food grains. Classification, structure and physico-chemical properties and thermal properties of Food grains; Unit operations and equipment for Food Grain Processing- Cleaning, sorting, grading, drying, storage, milling; Processing and storage of cereals, pulses and oil seeds. Commercial processing of Paddy, wheat, Corns, Barley, Millets, Pulses and Oil seeds.

**Essential Reading:**
1. Post harvest technology of Cereals, Pulses and Oil Seeds by A Chakravarti
2. Unit Operations in Agricultural Processing by Sahay and Singh
3. Food Process Engineering and technology by I A Ansary

Supplementary Reading:
1. Unit operations of chemical engineering by McCabe and Smith.

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<th>FP 2301</th>
<th>Horticultural Product Processing</th>
<th>3 credits [3-0-0]</th>
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**Objective:** To learn various processes and methods of Horticultural Products

**Syllabus:**
Production and processing scenario of horticultural products; basics of ripening, maturity, harvesting, handling, packaging, transport, storage and Quality of fruits and vegetables. Principles, unit operations and Equipment for processing and preservation of fruits and vegetables. Processing technology for jam, jelly, marmalade, preserve, pickles, chutneys, ketchups, sauces, beverages, powder and canned products.

**Essential Reading:**
1. Preservation of Fruits and Vegetables, by Lal, Siddappa and Tandon
2. Fruit and Vegetable Preservation: Principles and Practices by Srivastava and Kumar

**Supplementary Reading:**
1. Fruit Manufacturing by J E Lozano
2. Handbook of Vegetable and Vegetable processing by N K Sinha

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<th>FP 2202</th>
<th>Food Processing Operations - II</th>
<th>3 credits [3-0-0]</th>
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**Objective:** To learn various mass transfers related unit operations in food processing

**Syllabus:**
Contact equilibrium process, extraction process, rate of extraction, stage-equilibrium extraction, solvent extraction, supercritical fluid extraction, extraction equipment. Crystallization, crystallization equipment. Size reduction: Grinding, Cutting, Emulsification, homogenization, energy concept in size reduction, Kick's law, Rittinger's law, Bond’s law. Grinding and milling equipment. Mechanical separations: Sedimentation and filtration, membrane separations, Sieving / Screening, Sieve analysis. Parboiling, Extrusion, Frying, Baking, Roasting, Puffing, Agitation and mixing, Irradiation and non-thermal processing operations.

**Essential Reading:**
1. Unit Operations in Food Processing by R.L.Earle, Published by NZIFST (Inc.)
2. Unit operations in Food Engineering by A. Ibarz and Gustavo V Barbosa-Canovas
3. Fundamentals of Food Process Engineering by R.T.Toledo, Published by Springer
4. Food Process Engineering and Technology by ZekiBerk, Published by ELSEVIER

**Supplementary Reading:**
5. Food Processing Handbook, by J.G.Brennan, Published by WILEY-VCH Verlag GmbH & Co. KGaA
6. Unit operations of chemical engineering by McCabe and Smith. Published by McGraw-Hill
7. Dairy plant engineering and management by Tufail Ahmad. Published byKitab Mahal Publications
8. Engineering for dairy and food product by Farrall A.W. Published by John Wiley and Sons
FP 2104  Food Microbiology and Safety Laboratory  1 credits [0-0-2]

Objectives: To learn basics of microbiology in food processing

Syllabus:

Essential Reading:
1. Food Microbiology Laboratory by McLandsborough. CRC Press
2. Laboratory Methods in Food Microbiology by Harrigan. Gulf Professional Publishing

Supplementary Reading:
3. Practical Food Microbiology by Diane Roberts, Melody Greenwood, Wiley
4. Laboratory Manual of Food Microbiology by Garg, Garg, Mukerji.

FP 2403  Food Grains and Horticulture Processing Laboratory  2 credits [0-0-3]

Objective: To learn various processes and methods of Food Grain and Horticultural Processing

Syllabus:
Physical properties of cereals, pulses and oil seeds, Milling Characteristics of Food Grains, Size reduction and sieve analysis. Study of temperature and time on parboiling of rice, Effect of parboiling on nutrient content of paddy. Determination of cooking quality of rice, Determination of gelatinization temperature of rice, Study on cooking quality of pulses. Determination of Oil Content. Methods for Oil expressions. Preparation of fruit jam from Fruits, Preparation of fruit jelly from Fruits, Preparation of Jelly, Squash, Qualitative determination of pectin content by alcohol test / jelmeter test in fruit extract, Preparation of ready to serve (RTS) from mango/ litchi/ lemon, Preparation of fruit leather - mango leather, Preparation and preservation of tomato puree and ketchup

Essential Reading:
1. Unit Operations in Agricultural Processing by Sahay and Singh
2. Fruit and Vegetable Preservation: Principles and Practices by Srivastava and Kumar

Supplementary Reading:
1. Post harvest technology of Cereals, Pulses and Oil Seeds by A Chakravarti

FP 3501  Dairy Process Engineering  3 credits [3-0-0]

Objective: To understand the principles of Dairy processing and milk products processing

Syllabus:
Milk reception and principals of milk processing: milk storage, bulk cooling, stirring and mixing, pasteurization, sterilization, centrifugation, homogenization, evaporation and condensation. Spray drying of milk, principle and equipment: spray dryer, cyclone separator. Manufacturing of milk products and principles of processing of cheese, ice-cream, butter, special milk products,
casein, whey, curd, butter milk etc. Equipment for indigenous milk products manufacturing. Milk ultra-filtration and reverse osmosis. Filling Operations: Principles and working of different types of bottle filters and capping ma-chine, pouch filling machine, pre-pack and aseptic filling. Filling and Packaging machines for milk and milk products, aseptic packaging. Bulk milk handling system, care and maintenance. Hygienic design concepts, sanitary pipes and fittings, CIP system. Preventive maintenance program for Dairy Plant. Maintenance organization, development of optimum organization planned overhaul and PERT plan-ning, Utilities and sanitation in processing plant. Manufacturing of milk products and principles of processing of fluid dairy products, fat rich dairy products such as cream, butter, butter-oil, frozen dairy products such as ice-cream, fermented dairy products such as cheese and yoghurt, evaporated dairy products, dried dairy products, dairy by-products, indigenous dairy products.

**Essential Reading:**
1. Dairy processing handbook by Tetrapak.
2. Engineering for dairy and food products by A W Farrall. John Wiley and Sons
3. Outlines of dairy technology by Sukumar De. Oxford University Press

**Supplementary Reading:**
1. Indian dairy products by K S Rangappa Asia Publishing House
2. Cheese and Butter by V. Cheke and A. Sheeprd, Agrobios (India)
4. Milk and Milk Products by Eckles and Eckles

**FP 3601 Food Packaging and Storage Engineering** 3 credits [3-0-0]

**Objective:** Understanding of food packaging development, packaging systems and analyze complex systems of food packaging and logistics with simulation models.

**Syllabus:**

**Essential Reading:**
3. Food Packaging and Preservation by M. Mathlouthi. Blackie Academic & Professional

**Supplementary Reading:**
FP 3105  
**Food Analysis and Quality Control**  
3 credits [3-0-0]

**Objectives:** To provide a basic understanding of Food analysis and concepts of quality control in food processing.

**Syllabus:**
- Quality Control and its importance, Methods of colour determination and their applications.
- Food flavors, factors affecting food product flavours, measurement of food flavours, theory of taste and smell.
- Food Rheology and viscosity: Shear stress, shear rate, torque, Newtonian and Non-Newtonian flow and their further classification.
- Factors affecting consistency and viscosity, measurement of vis-cosity and consistency.
- Food texture, Physical characteristics of food, working of texture measuring instruments, Fruit pressure tester, puncture tester, succulometer, tenderometer, texturometer, ma-turometer, fibrometer, Texture Profile Analysis (TPA).
- Non Destructive Methods for food analysis, Near Infrared Spectroscopy (NIR), Nuclear Magnetic Resonance (NMR) and its application, Ultrasonic equipments, conductivity and resistivity meters.
- Principle and working of Gas chromatography (GC), High pressure liquid chromatography (HPLC), types of detectors used in GC and HPLC, Thin layer chromato-graphy (TLC), Column Chromatography, chromatographic methods applied as quality control.
- Sensory evaluation: Objectives, panel selection, Different test methods and their groups such as difference tests, rating tests, sensitivity tests.
- Sensory scores, Food Safety and Regulations: Food Safety and Standards Act, Codex Alimentarius, ISO series, Good Manufacturing Practices (GMP), Good Hy-gienic Practices (GHP), Good Agricultural Practices (GAP), Genetically Modified Foods (GMF).

**Essential Reading:**
1. Pearson’s Composition and Analysis of foods, by S Ronald, Addison & Wesley Publisher
   Quality Control for Food Industry. Vol I and II AVI Publications by A Krammer
2. Food Quality Control by Manoranjan Kalia

**Supplementary Reading:**

FP 3203  
**Food Engineering Laboratory**  
2 credits [0-0-3]

**Objective:** To learn the basic concept of heat and mass transfer in food processing

**Syllabus:**
- Introductory concepts, modes of heat transfer, thermal conductivity of materials, measurement.
- General differential equation of conduction. One dimensional steady state conduction through plane and composite walls, tubes and spheres with and without heat generation.
- Newton’s law of cool-ing, heat transfer coefficient in convection. Dimensional analysis of free and forced convection. Useful non dimensional numbers and empirical relationships for free and forced convection.
- Equation of laminar boundary layer on flat plate and in a tube. Laminar forced convection on a flat plate and in a tube. Combined free and forced convection.
- Introduction. Absorptivity, reflectivity and transmissivity of radiation. Black body and monochromatic radiation, Planck’s law, Stefan-Boltzman law, Kirchoff’s law, grey bodies and emissive power, solid angle, intensity of radiation. Radiation exchange between black surfaces,

Essential Reading:
1. Biological and Bioenvironmental Heat and Mass Transfer by Datta
2. Heat And Mass Transfer By Nag

Supplementary Reading:
1. Food Processing Handbook, by J.G.Brennan, Published by WILEY-VCH Verlag GmbH & Co. KGaA
2. Unit operations of chemical engineering by McCabe and Smith. Published by McGraw-Hill

FP 3502 Dairy Process Engineering Laboratory Dairy Process Engineering Laboratory 2 credits [0-0-3]

Objectives: To understand the hygienic characteristics of dairy plant and various dairy processes.

Syllabus:
Identification of hygienic characteristics of pipes and fittings in dairy plant; To study CIP system for dairy plant; description of technical specifications of milking and storage equipment; description of technical specifications of equipment for chilling & pasteurization; description of features of centrifuges and operation; working principle of ice-cream freezers & packing machine; design and principle of working of cheese vat; working principle of milking machine; working principle of press & packing machine; description of butter manufacturing equipment; description of different types of evaporators used in dairy industry; description of different types of dryers used in dairy industry; description of operation of spray dryers used in dairy industry; operation of drum an vacuum dryers used in dairy industry; design of milk collecting and chilling unit; Visit to dairy industry

Essential Reading:
1. Dairy Plant System and Layout by Tufail Ahmed
2. Text Book of Dairy Chemistry by Mathur, M.P., Datta, Roy, D. and Dinakar, P

Supplementary Reading:
1. Objective questions in Dairy science and technology and food and dairy engineering by Harish sharma, H pandey, G singh.

FP 3602 Food Packaging and Storage Design Laboratory Food Packaging and Storage Design Laboratory 1 credits [0-0-2]

Objectives: To gain knowledge about different kind of packaging and storage of Food.

Syllabus:
Classification of various packages based on material and rigidity; Measurement of thickness of paper, film, paper boards; Determination of wax weight in paper packaging; Measurement of grammage and water absorption of paper of paper boards; Measurement of bursting strength of paper of paper boards; Measurement of tear resistance of packaging material; Measurement of puncture resistance of packaging material; Measurement of tensile strength of packaging material; Measurement of grease resistance of papers; Determination of gas transmission rate of package films; Determination of coating on package materials; Identification of plastic films; Study of packaging film for their labelling characteristics and specifications; Pre-packaging
practices followed for packing fruits, vegetables; Demonstration of can-seaming operation; Determination of shelf life of food product.

**Essential Reading:**
3. Grain Storage Engineering and Technology, Batra Book Services by Vijayaraghavan, S.
4. Food Packaging and Preservation by M. Mathlouthi. Blackie Academic & Professional

**Supplementary Reading:**
5. Silos, Theory and Practice: Vertical Silos, Horizontal Silos (retaining Walls), 2nd Ed, Lavoisier Pub. by André M. Reimbert

**FP 3302  Processing of Spices, Condiments and Plantation crops For Packaging and Storage Design Laboratory  3 credits [3-0-0]**

**Objectives:** To gain knowledge about processing of Spices, Condiments and Plantation crops

**Syllabus:**
Classification, composition, structure and characteristics. Production status of spices in India: major spice producing area in India and world wide, export potential of processed and raw spice product. Processing of major and minor spices: Preservation and processing of major and minor spices of India; Processing of whole spice, spice powder, paste and extracts; production and processing of spice mixtures; spice oils and oleoresins, functional role of spices, quality specification for spices. Tea Processing: Composition and production of tea leaves; processing of tea leaves; CTC tea, black tea, green tea and Oolong tea, grading and packaging; processing of instant tea. Coffee Processing: Production and processing of coffee cherries by wet and dry method; processing technology for coffee; preparation of brew; processing technology for instant coffee and decaffeinated coffee. Cocoa processing: Cocoa bean introduction, history and composition; processing of cocoa bean; processed products of cocoa.

**Essential Reading:**

**Supplementary Reading**

**FP 3204  Food Process Equipment and Plant Design Food Packaging and Storage Design Laboratory  3 credits [3-0-0]**

**Objectives:** To conceptualize and design equipment needed for various food processing operations.
Syllabus:

Essential Reading:
1. Process equipment design by Joshi MV and Mahajan VV. Published by Macmillan India Ltd
2. Process equipment design by Brownell and Young. Published by John Willey
3. Food Plant Economics by Z.B. Maroulis and G.D. Sarvacos. Published by CRC press
4. Chemical Engineering Plant Design by Villbrandt F.C. and Dryden C.E. Published by McGraw-Hill

Supplementary Reading
5. Plant Layout and Design by J.M. Moore Published by The Mcmillan company

FP 3404 Bakery and Confectionary TechnologyFood Packaging and Storage Design Laboratory 3 credits [3-0-0]

Objectives: To learn various aspects of Bakery and Confectionary technology.

Syllabus:
Historical development and status of bakery industry in India; introduction and definition of bakery products-bread, biscuit, cake, pastries, rusk, crackers. PFA specifications of bakery products. Bread- types; role of major and minor ingredients; processes of bread making; problems associated with bread; equipment for bread manufacturing; processing steps for biscuit, cookies, cracker, cakes and their major and minor ingredients. Nutritional aspect of bakery products; quality evaluation of baked products. Confectionary- historical development; classification of confectionary products; basic technical considerations for confectionary products, raw materials and their role in confectionary product; traditional confectionary products. Cocoa bean- introduction, history and composition; processing of cocoa bean; processed product of cocoa; historical development in chocolate processing; ingredients and their role in chocolate; processing steps of chocolate processing- mixing, refining, conching, tempering, molding, cooling, coating, enrobing etc. High boiled sweets/candy - composition, production and preparation of high boiled sweets- traditional, batch and continuous method; toffee- composition, types, ingredient and their role, batch and continuous method of toffee manufacturing;

Essential Reading:
1 Biscuit, cracker and cookie recipes for the food industry, Woodhead Publishing Ltd and CRC Press LLC by Duncan Manley
2 Baking problems solved Woodhead Publishing Ltd and CRC Press LLC by S Cauvain and L Young

Supplementary Reading
4 Flat Bread Technology, Chapman & Hall by J. Qarooni

FP 3503 Processing of Livestock, Fish and Marine Products Food Packaging and Storage Design Laboratory 3 credits [3-0-0]

Objective: To learn various processes and methods for Processing of Livestock, Fish and Marine Product

Syllabus:
Production, Economics, and processing scenario of meat, fish and poultry. Preservation of meat- de-hydration, freezing, pickling, curing, cooking and smoking; dehydration; curing; preservation of meat using ionizing radiation; preservation of meats using- antibiotics and chemical preservatives. Eating quality of meat and discoloration; water-holding capacity and juiciness in cooked and uncooked meat; texture and tenderness- definition and measurement, factors affecting texture and tenderness, artifi-cial tenderizing. Abattoir design and layout, meat plant sanitation and safety, by-products utilization. Processing and preservation of eggs, production of egg yolk and egg yellow powder. Poultry pro-cessing: Unit operations for various poultry products; Fish processing: Unit operations for various fish products;

Essential Reading:
1. Meat Science by Lawrie

Supplementary Reading
3. Egg Science and Technology by Stadelmen and Cotterill
4. Muscle as Food by Bechtel

FP 3603 Food Refrigeration and Cold Chain Food Packaging and Storage Design Laboratory 3 credits [3-0-0]

Objective: To study the principles of heating, ventilating, air conditioning and refrigeration systems and enable students to achieve effective and efficient design solutions.

Syllabus:
refrigerated product handling, order picking, refrigerated vans and refrigerated display. Refrigeration load estimation.

**Essential Reading:**
1. Principles of Refrigeration by Dossat R.J. Published by John Wiley
2. Advances in food refrigeration by Da Wen Sun. Published by Woodhead Publishing Limited, UK

**Supplementary Reading:**
1. Refrigeration and Air-conditioning by CP Arora. Published by Tata McGraw Hill
2. Refrigeration and Air-conditioning by Manohar Prasad. Published by New Age publications.
3. Commercial Cooling of Fruits and Vegetables by Thompson. Published by Univ. of California

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**FP 3604  Food Refrigeration and Cold Chain Laboratory**
- Food Packaging and Storage Design Laboratory
  - 2 credits [0-0-2]

**Objectives:** To understand refrigeration cycle principles as it applies to installing, working and trouble-shooting of equipment.

**Syllabus:**

**Essential Reading:**
1. Principles of Refrigeration by Dossat R.J. Published by John Wiley
2. Refrigeration and Air-conditioning by Manohar Prasad. Published by New Age publications.
3. Refrigeration and Air-conditioning by CP Arora. Published by Tata McGraw Hill

**Supplementary Reading:**
1. Advances in food refrigeration by Da Wen Sun. Published by Woodhead Publishing Limited, UK
2. Commercial Cooling of Fruits and Vegetables by Thompson. Published by Univ. of California

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**FP 3106  Food Analysis and Quality Control Laboratory**
- 1 credits [0-0-2]

**Objectives:** To gain knowledge of various methods for food quality analysis and control.

**Syllabus:**
Training of sensory panel for flavor perception; sensitivity tests for four basic tastes; difference tests, triangle test, paired comparison test, duo trio test; Sensory evaluation of milk and detection of flavour defects in milk; Sensory evaluation of food samples for textural properties; detection of common adulterants- formaldehyde, starch, cane sugar, hydrogen peroxide, sodium bicarbonate in milk; Test for the presence of sesame oil in given oil sample; Colour estimation of food samples by tintometer; Examination of fruit jams for FPO specifications; Examination of Butter / oil samples for AGMARK specifications; Examination of food / milk products for BIS specifications; determination of BAR (Brix acid ratio) in beverages; Visit to units with ISO 22000:2005 certified company; Evaluation of food labels of products for PFA.
standards; Determination of total residual chlorine in water sample; Cut out analysis of Canned Product samples.

**Essential Reading:**
1. Food Chemistry by Meyer
2. Food Chemistry by Fennema
3. Basic Food Chemistry by Lee

**Supplementary Reading:**
1. Food Chemistry by Belitz
2. Principles of Biochemistry by Lehninger

**FP 3107 Food Product Technology laboratory** 2 credits [0-0-3]

**Objectives:** To learn various methods of Bakery and Confectionary technology.

**Syllabus:**

**Essential Reading:**
1. Biscuit, cracker and cookie recipes for the food industry, Woodhead Publishing Ltd and CRC Press LLC by Duncan Manley
2. Baking problems solved Woodhead Publishing Ltd and CRC Press LLC by S Cauvain and L Young

**Supplementary Reading**
4. Flat Bread Technology, Chapman & Hall by J. Qarooni

**FP 4205 Food Process Equipment and Plant Design Laboratory** 2 credits [0-0-3]

**Objective:** To acquire basic understanding of design parameters, design procedures for food process equipment and their attachments in food processing plant.

**Syllabus:**
Essential Reading:
1. Process equipment design by Joshi MV and Mahajan VV. Published by Macmillan India Ltd
2. Process equipment design by Brownell and Young. Published by John Willey
4. Plant Layout and Design by J.M. Moore. The Mcmillan company

Supplementary Reading:
1. Process equipment design by Bhattacharya BC. Macmillan India Ltd
2. Strength and elasticity of materials by Brooks WH. Asia Publishing House

ELECTIVE COURSES

FP-4206 Emerging Technologies in Food Processing 3 credits [3-0-0]

Objectives: To learn about various emerging technologies in Food Processing Sector

Syllabus:
Introduction, scope and applications of High pressure processing of foods, Pulse electric fields processing (PEF), Osmotic dehydration, High intensity pulsed light Technology, Food Processing by Radio frequency Electric fields and electromagnetic radiations, Ultrasound in food processing, Food Irradiation. Recent Development in Microwave heating; Radio-Frequency processing; Ohmic heating; Com-bine Microwave Vacuum drying; New Hybrid Drying technologies; Vacuum cooling of foods; Concept of Minimal processing of Fruits and Vegetables products; Modified and Controlled Atmospheric Pack-aging for Minimally processed foods. Any other latest technologies for food processing.

Essential Reading:
1. 
2. 4. Thermal Food Processing – New technologies and Quality Issues by Da-Wen Sun
2. Advances in Thermal and Non-Thermal Food Preservation by Tewari and Juneja

Supplementary Reading:
1. Innovation in Food Engineering – New Techniques and Products by Passos and Ribeiro

FP-4207 Food Industry By-Product and Waste Management 3 credits [3-0-0]

Objective: To learn various methods and techniques for Food Industry by-product and waste Management

Syllabus:
Various byproducts from Food Processing Industry: By products of cereals, legumes, oil seeds, dairy, fruit and vegetables processing industries and their uses. By products of meat and fish processing units and their uses. Uses of byproducts of agro based industries in various sector. Various laws and regula-tions for waste management in food processing industries, Food industry wastes, Waste treatment methods for Cereals, Fruits, vegetables, Meat, Fish, Dairy processing and Brewery Industries. Waste water treatment, zero-discharge and zero-emission system.
Essential Reading:
1. Utilization of By-Products and Treatment of Waste in the Food Industry by Oreopoulou and Russ
2. Handbook of Waste Management and Co-Product Recovery in Food Processing by Waldron

Supplementary Reading:
1. Waste Management for the Food Industries by Arvanitoyannis

FP-4303 Beverage Technology 3 credits [3-0-0]

Objectives: To describe the characteristics and production methods of both alcoholic and non-alcohol-ic beverage types.

Syllabus:
Types of beverages and their importance; status of beverage industry in India; Manufacturing technology for juice-based beverages; synthetic beverages; technology of still, carbonated, low-calorie and dry beverages; isotonic and sports drinks; role of various ingredients of soft drinks, carbonation of soft drinks. Specialty beverages based on tea, coffee, cocoa, spices, plant extracts, herbs, nuts, dairy and imitation dairy-based beverages. Alcoholic beverages- types, manufacture and quality evaluation; the role of yeast in beer and other alcoholic beverages, ale type beer, lager type beer, technology of brewing process, equipment used for brewing and distillation, wine and related beverages, distilled spirits. Packaged drinking water- definition, types, manufacturing processes, quality evaluation and raw and processed water, methods of water treatment, BIS quality standards of bottled water; mineral water, natural spring water, flavoured water, carbonated water.

Essential Reading:
1. Handbook of Brewing by Hardwick WA.
2. Handbook of Food and Beverage Fermentation Technology by Hui.
3. Handbook of Brewing by Priest and Stewart.

Supplementary Reading:
1. Beverages: Technology, Chemistry and Microbiology by Varnam and Sutherland

P-4208 Experimental Design and Statistical Methods 3 credits [3-0-0]

Objectives: To learn about various methods experimental design and statistical methods

Syllabus:
Descriptive statistics, Mean, Variance, Probability, Probability distribution. Data and its nature, data representation, diagrams and graphs using MS Excel, Measure of central tendency, Dispersion, Swe-kness and Kurtosis. Basic statistical concepts, concepts Strategy of experiments, basic principles, guide-lines for designing experiments and importance of designed experiments in research. Full factorial de-sign, 2K design, completely randomized design, randomized block design, central composite design, factorial design, Box Behenken design, Analysis of variance. Introduction to theory of estimation and confidence-intervals, Correlation and Regression, Simple and multiple linear regression model, Partial correlation coefficient, test of significant of correlation coefficient and regression coefficient, Coeffi-cient of determination, Testing of heterogeneity. Multivariate relationships, multiple linear regression, multiple and partial correlation, significance of testing in multiple correlation, variable selection in mul-tiple regression. Multiple regression analysis, variable selection.
Essential Reading:
1. Statistical Methods by W. G. Cocharan
2. Statistical Methods S Chand & Sons, by S P Gupta
3. Computer aided techniques in Food Technology by Israel Saguy
4. Basic Statistics, New Age Publishers, by B L Aggarwal

Supplementary Reading:
1. Response surface methodology by R. H. Myers
2. Response surfaces design and analysis by A. I. Khuri & J. A. Cornell

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FP-4209 Separation Techniques in Food Processing 3 credits [3-0-0]

Objectives: To learn the fundamentals of various separation technologies applicable in Food Processing

Syllabus:
Introduction to various separation processes; Gas-Liquid, Gas-Solid, Liquid-Liquid, Liquid-Solid separation; Concept of phase equilibrium; Impingement separator; Electrostatic precipitation; Distillation-Application of distillation in food processing; Membrane separation technology – Introduction to micro-filtration, ultra-filtration, nano-filtration, reverse osmosis, electro dialysis; Physical characteristics of membrane separation; Factor affecting reverse osmosis process; Concentration of polarization; Design of reverse osmosis and ultra-filtration system; Operation layout of the modules; Electro dialysis; Pervaporation; Fabrication of membrane; Application of membrane technology in food industry. Powder Technology; Classification of powder; Separation of powder; Sieving; Air classification; Factor affecting air classification; Cyclone application; Air separation; Particle size distribution; Super critical fluid (SCF) extraction - Introduction; Properties of SCF; Food application of SCF; Application of SCFE in analytical technique and pharmaceutical application.

Essential Reading:
1. Elements of Mass Transferring, PHI by Anantharaman N and Begum KMMS
2. Mechanical Operations for Chemical Engineers, Khanna Publisher by Narayanan CM and Bhattacharyya BC

Supplementary Reading:
1. Solid-Liqis Filtration and separation Technology by A. Rushton, A S Ward & R G Holdich, Publisher-Wiley-VCH

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FP-4108 Food Laws, Regulations and Certifications 3 credits [3-0-0]

Objective: To learn various Laws, Regulations & Certifications for Food Processing

Syllabus:
Food Adulteration, Food Safety Management System. Mandatory and voluntary food laws. Various laws, regulations and Certifications for food processing. Essential Commodity Act, Prevention of Food Adulteration Act (PFA), Fruit Products Order (FPO), Meat Food Products Order (MFPO), Vegetable Oil Control Order, Agricultural Marketing and Grading Standards (AGMARK), Bureau of Indian Standards(BIS) and their certifications, Food Safety and Standards Authority of India (FSSAI), Food Safety and Standards Act and Regulations of India. Food Codex laws, Food and Drug Administration (FDA), International Organization for Standardization (ISO), Good Manufacturing Practices (GMP), Good Agri-cultural Practices (GAP), Hazard Analysis and Critical
Control Point (HACCP).

Essential Reading:
1. Food Regulation: Law, Science, Policy, and Practice by Fortin
2. Food Safety and Standards Act and Regulations by FSSAI

Supplementary Reading:
3. Dev Raj, Rakesh Sharma and Joshi V.K, Quality for Value Addition in Food Processing.
4. EU food law by K Goodburn: CRC press

FP 4109 Food Ingredients and Additives 3 credits (3-0-0)

Objectives: To understand the fundamentals of food ingredients and food additives and their role.

Syllabus:
Food ingredients and additives- definitions, classification and functions, need for food ingredients and additives, food preservatives, classifications, antimicrobial agents (types, mode of action and their application); Nutrient supplements & thickeners, polysaccharides, bulking agents, antifoaming agents, synergists, antagonists. Antioxidants (synthetic and natural, mechanism of oxidation inhibition), chelating agents: types, uses and mode of action Coloring agents: color retention agents, applications and levels of use, natural colorants, sources of natural color (plant, microbial, animal and insects), misbranded colors, color extraction techniques, color stabilization.Flavoring agents: flavors (natural and synthetic flavors), flavor enhancers, flavor stabilization, flavor encapsulation; Flour improvers: leavening agents, humectants and sequesterants, hydrocolloids, acidulants, pH control agents buffering salts, anticaking agents, etc. Sweeteners: natural and artificial sweeteners, nutritive and non-nutritive sweeteners, properties and uses of various sweeteners in food products; Emulsifiers: Types, selection of emulsifiers, emulsion stability, functions and mechanism of action. Additives, food uses and functions in formulations; permitted dosages.

Essential Reading:
1. Natural food additives, ingredients and flavourings by D. Baines.
2. Fenaroli’s Handbook of Flavor Ingredients by Gerorge
3. Food Flavours, Part A, B & C by Morton and Macleod

Supplementary Reading:
1. Food Antioxidants: Technological,Toxicological and Health Perspective by Madhavi, Deshpande and Salunkhe

FP-4210 Food Business Management & Entrepreneurship 3 credits [3-0-0]

Objectives: To learn various aspects of Business management and entrepreneurship development in food processing

Syllabus:
Introduction and definitions related with project management and entrepreneurship; Fundamentals of project management and entrepreneurship development; Project formulation: market survey techniques, project identification, project selection, project proposal, work breakdown structure;
Network scheduling: activity, networks, use of CPM, PERT in project scheduling. Resource planning, resource allocation, project scheduling with limited resources. Estimation of project costs, earned value analysis, project techno-economic viability, break-even analysis. Identification of business opportunity in food processing sector, Government policies for promotion of entrepreneurship in food processing. Launching and organizing an enterprise, enterprise selection, market assessment, feasibility study, SWOT analysis, resource mobilization. Financial institution in promoting entrepreneurship; Supply chain management.

**Essential Reading:**
1. Management and Engineering by Gail Freeman Bell and James Balkwill. Prentice Hall International

**Supplementary Reading:**
2. Entrepreneurship and Management inputs for entrepreneurs in Food Processing Sector by Dinesh Awasthi and Rama Jaggi

**FP-4110 Functional Foods and Nutraceuticals** 3 credits [3-0-0]

**Objectives:** To understand concepts of functional and nutraceutical food and their role in different disease control

**Syllabus:**

**Essential Reading:**
2. Functional Foods Concept to Product by Glenn R. Gibson and Christine M. Williams, Woodhead Publishing Limited and CRC Press LLC

**Supplementary Reading:**

**FP-4211 Process Control and Instrumentation in Food Industry** 3 credits [3-0-0]

**Objectives:** To learn process control and instrumentation in food processing industry

**Syllabus:**
Instruments for temperature, pressure, humidity measurements- types, calibration. Pressure gauge, basic concept of pneumatic pressure transmitter, pressure current and pressure resistance transducers. Positive displacement meter, Weight measurement- mechanical scale, electronic tank scale, conveyor scale, measurement of specific gravity, measurement of humidity, measurement of viscosity, measurement of density, automatic valves. Definition of process control, simple system analysis, dynamic behavior of simple process, Laplace transform, process control hardware. Frequency response analysis, frequency response characteristics, Bode diagram and Nyquist plots and stability analysis. Ionization techniques, scanning technique, application of GC/MS, LC/MS /FAB/MS /MS/MS and Linked scan techniques. Basic principles of chromatography. Paper

**Essential Reading:**
2. Instrumental Methods of Chemical Analysis, Goel Publishing House, New Delhi by B. Sharma.

**FP-4111 Biochemistry and Human Nutrition 3 credits [3-0-0]**

**Objectives:** To learn biochemistry and nutritional aspect of foods

**Syllabus:**
Nutrition, malnutrition, functions of food, basic food groups, nutritional needs, requirements and recommended allowances of foods; Mechanism of enzyme action, coenzymes, enzyme kinetics, Derivation of Michaelis-Menten Equation. Sources, functions, digestion, absorption, assimilation and transport of carbohydrates, proteins and fats in human beings. Metabolism of carbohydrates: Respiration (TCA cycle), Metabolism of lipids, Metabolism of proteins. Functions, sources, factors affecting absorption of minerals, absorption promoters and inhibitors, effect of deficiency of Calcium, phosphorus, iron, zinc, iodine, fluorine and copper. Vitamins and hormones: Classification, functions, sources, effects of deficiency. Changes during food processing operations, restoration, enrichment, fortification and supplementation of foods.

**Essential Reading:**
1. Principles of Biochemistry by A L Lehninger
2. Text book of Biochemistry by E S West, W R Todd, H S Mason and J T Van Bruggen
3. Nutrition and Dietetics, Tata McGraw-ill Co. Ltd by Shubhangini A Joshi

**Supplementary Reading:**
1. General Biochemistry by J H Weil
3. Food Chemistry, Marcel Dekkar Inc by O R Fennema
4. Essentials of Nutrition, Ganesh and Co by M Swaminathan
5. Outlines of biochemistry by Eric E Conn and P K Stumpf

**FP-4212 IT Applications in Food Industry 3 credits [3-0-0]**

**Objectives:** To learn various applications of information technologies in food processing industry

**Syllabus:**
Importance of computerization and IT in food industry, operating environments and information systems for various types of food industries, principles of communication. Role of computer in Optimization. Introduction to Toolboxes useful to Food Industry; Curve fitting toolbox, Fuzzy logic toolbox, Neural Network toolbox, Image processing toolbox, statistical toolbox. Applications of CFD in Food and beverage industry. Introduction to CFD softwares. Introduction to Supervisory Control and Data Acquisition (SCADA); SCADA systems hardware and firmware SCADA systems software and protocols Landlines, Online food process control from centralized server system in processing plant. Introduction to MATLAB; MATLAB interactive sessions, computing with MATLAB; MATLAB help system, problem solving methodologies; Functions and
Files in MATLAB, Programming using MATLAB, Program design and development, debugging MATLAB programs; Plotting and Model Building in MATLAB.

**Essential Reading:**
1. Computer Applications in Food Technology: Use of Spreadsheets in Graphical, Statistic and Process Analysis by R. Paul Singh, AP. Published by Academic Press
2. Introduction to MATLAB 7 for engineers by William J. Palm. Published by McGraw Hill Professional
3. Computation Fluid Dynamics in Food Processing by Da Wen Sun. Published by CRC press

**Supplementary Reading:**
1. Web Design: A Complete Introduction by Jenny Chapman. Published by John Wiley & Sons
2. Practical SCADA for Industry by David Bailey and Edwin Wright. Published by Elsevier

**FP-4231 Food Process Modeling and Simulation 3 credits [3-0-0]**

**Objectives:** To learn application of modeling and simulations in food processing

**Syllabus:**
Fundamentals of modeling and simulation; Definition of basic terms like system, entity attribute, activity, state of system, system environment; Different steps for modeling and simulation, Types of models; Advantages of modeling and simulation; Monte Carlo Method or random simulation, Application areas of simulation. Iterative convergence method, derivation and algorithm of bisectional method or intermediate value theorem; Regula Falsi method; Newton Raphson method, Generalized Newton’s method for multiple roots, Iterative or method of successive approximation; Introduction to numerical integration, Simpson’s 1/3rd rule, Solution of Ordinary Differential Equation Model: Picard Method, Taylor’s Series method, Euler’s method, Modified Euler’s method, Runga Kutta method. Solution of partial differential equations models: Differential Laplace, Poisson, parabolic and hyperbolic equation, Finite difference method, graphical method, Bender - Schmidt method. Introduction to optimization, optimization methods, Graphical and numerical methods of optimization, Unconstrained and Constrained optimization, Programming optimization, experimental optimization, Response surface methodology (RSM). Modelling and simulation of selected food engineering operations.

**Essential Reading:**
1. Computerized Control Systems in the Food Industry by Gauri S. Mittal
2. Computer aided techniques in Food Technology by Israel Saguy

**Supplementary Reading:**
1. Design of Experiments by Montgomery
### DEPARTMENT OF INDUSTRIAL DESIGN ENGINEERING

**DETAILED SYLLABI OF COURSES**

**B Tech**

**DEPARTMENT OF INDUSTRIAL DESIGN**

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<tr>
<td>2</td>
<td>ID2102</td>
<td>Art &amp; Aesthetics in Design</td>
<td>3-0-0</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>ID2103</td>
<td>Design Elements</td>
<td>3-0-0</td>
<td>3</td>
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<tr>
<td>4</td>
<td>ID2104</td>
<td>Design Thinking</td>
<td>3-0-0</td>
<td>3</td>
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<tr>
<td>5</td>
<td>ID2106</td>
<td>Design Thinking for Engineers</td>
<td>3-0-0</td>
<td>3</td>
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<tr>
<td>6</td>
<td>ID2202</td>
<td>Materials &amp; Processes for Design</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>ID2701</td>
<td>Design Workshop-I</td>
<td>0-0-2</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>ID2702</td>
<td>Design Workshop-II</td>
<td>0-0-3</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>ID2704</td>
<td>Visual Communication Laboratory</td>
<td>0-0-3</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>ID2706</td>
<td>Design Practice-I</td>
<td>0-0-2</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>ID3101</td>
<td>Communication Design</td>
<td>3-0-0</td>
<td>3</td>
</tr>
</tbody>
</table>
### Analysis of history of Art, Traditional Arts, Modernity and Post-Modernity

Relationship between syntactics, semantics and pragmatics. Exploration of surface textures in different materials. 2D and 3D Form Transition. Exploration of form to develop imagination and insight. Use of metaphors to generate new forms. Concept of family of forms. Analysis of Aesthetics - the structure of Appearance. Form in nature. Exploration of visual images with analogies from nature.

Essential Reading:


Supplementary Reading:

5. Bachelard, Gaston; Jolas, Maria (Translator); The Poetics of Space, Publisher: Beacon Press; Reprint edition, 1994.


Essential Reading:


Supplementary Reading:


The purpose of this laboratory is to let the students develop the ability to do sketching, lettering, artistic work, etc. Related design projects in collaborative groups or on individual basis will work on a topic formulated by the concerned faculty member.
The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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</thead>
<tbody>
<tr>
<td>ID-2702</td>
<td>Design Workshop-II</td>
<td>2 [0-0-3]</td>
<td>Prof. Mohit Lal</td>
</tr>
</tbody>
</table>

Introduction to still life, human anatomy, nature study, colour, gradation, space, balance, texture and surface. The students need to develop product prototypes / models using thermocol, wood, POP, M-Seal. Creative design/art work on paper (Origami, Kirigami, Collage), with waste material.

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</tr>
</thead>
<tbody>
<tr>
<td>ID-2704</td>
<td>Visual Communication Laboratory</td>
<td>2 [0-0-3]</td>
<td>Prof. D.S. Bisht</td>
</tr>
</tbody>
</table>

The purpose of this lab is to let the students develop the ability to work on design softwares and on styling and rendering softwares like 3DMax, Photoshop, Rhino, etc. Related design projects in collaborative groups or on individual basis will work on a topic formulated by the concerned faculty member. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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</thead>
<tbody>
<tr>
<td>ID-2706</td>
<td>Design Practice-I</td>
<td>1 [0-0-2]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>

The purpose of this lab is to let the students develop the ability to work on solid modeling software like CATIA V6 and on styling and rendering software like Photoshop. Related design projects in collaborative groups or on individual basis will work on a topic formulated by the concerned faculty member.

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</thead>
<tbody>
<tr>
<td>ID-3201</td>
<td>Creative Engineering Design</td>
<td>4 [3-1-0]</td>
<td>Prof. D.P. Jena</td>
</tr>
</tbody>
</table>

Introduction: Example of different kinds of designs and designers, Design problems, Definition of Design, Engineering design and design research, Product life cycle, Morphology of design, Introduction to system design process, Stage models, Introduction to Task Clarification, Methods for identification of requirements, Quantifying requirements and Assigning importance to requirements, Linking Customer requirements to engineering requirements, Introduction to conceptual design Identification of functions, Ideation, Simulation and Consolidation into solution proposals, Methods for Identification of functions such as functional decomposition techniques, Methods for Ideation, such as Brainstorming, Synectics, etc., Methods for consolidation into solution proposals, such as Morphological charts, Morphological matrix, etc., Methods for simulation: analytical, virtual and physical simulations.

**Essential Reading:**


**Supplementary Reading:**

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</thead>
<tbody>
<tr>
<td>ID-3202</td>
<td>Interaction Design</td>
<td>3 [3-0-0]</td>
<td>Prof. D.S. Bisht</td>
</tr>
</tbody>
</table>

Design methodology for complex products, services and events. Design of integrated systems, products for future use, products to be used in groups, devices used in public places, design of multi-modal interfaces, expressive interfaces, products that enrich user experience. The course takes an inter-disciplinary approach drawing upon product design, visual communication, information architecture, cognitive psychology and computer science. The course involves exploration of alternatives, pushing the envelope of what is known. Human information processing, Human memory. Fitt's law, Hick's law. Human errors. Heuristic evaluation, cognitive walkthroughs. User testing using think aloud protocol and its variations. Field trials and user logs. GOMS. Theoretical models for evaluating products. The focus is on working collaboratively in groups to solve design problems. The course will involve doing projects. Students need to build soft prototypes of proposed systems at the end of the course.

**Essential Reading:**


**Supplementary Reading:**


<table>
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<th>Credit</th>
<th>Course Caretaker</th>
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</thead>
<tbody>
<tr>
<td>ID-3203</td>
<td>Introduction to Ergonomics</td>
<td>3 [3-0-0]</td>
<td>Prof. Mohit Lal</td>
</tr>
</tbody>
</table>

Data logging, data collection, data reduction and analysis techniques, gross human anatomy, anthropometry, bio mechanics, muscle strength, work capacity, environmental effects, exercises for evaluation of postural form and work spaces, environmental conditions including temperature, illumination, noise and vibration.

Introduction to man machine systems and ergonomics, Human factors in design and engineering, needs of ergonomics and aesthetic design, Physiological aspects of work, Work measurement through physiological tests, Work physiology, Paced and un–paced work performance.

**Essential Reading:**

1. J. Dul, Ergonomics for Beginners, Taylor & Francis, 2008

**Supplementary Reading:**

2. D. C. Alexander, Applied Ergonomics, Taylor & Francis, 2005

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</thead>
<tbody>
<tr>
<td>ID-3204</td>
<td>Product Design</td>
<td>3 [3-0-0]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>

The emphasis of the course is on group design projects. Selection of the projects is based on the possibility of user interaction leading to innovation. Projects end with a comprehensive presentation through working/mock up models, design drawing and a report. The project is supported by detailed discussion on various stages in the design process emphasizing the complimentary nature of systematic and creative thinking.

This is achieved by short supporting assignment in following topics: Creativity techniques like brainstorming & synectics to develop creative attitude and open mind, design opportunity, problem perception, Idea Sketching, clustering of ideas for concept development, exploratory mockup models for concept development, evaluation of concepts, final concept selection, concept development, refinement and detailing.

Essential Readings:


Supplementary Readings:


<table>
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<tr>
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<th>Credit</th>
<th>Course Caretaker</th>
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</thead>
<tbody>
<tr>
<td>ID-3205</td>
<td>Principles of Ergonomics</td>
<td>3 [3-0-0]</td>
<td>Prof. Mohit Lal</td>
</tr>
</tbody>
</table>

Data logging, data collection, data reduction and analysis techniques, gross human anatomy, anthropometry, bio mechanics, muscle strength, work capacity, environmental effects, exercises for evaluation of postural form and work spaces, environmental conditions including temperature, illumination, noise and vibration,

Introduction to man machine systems and ergonomics, Human factors in design and engineering, needs of ergonomics and aesthetic design, Physiological aspects of work, Work measurement through physiological tests, Work physiology, Paced and un-paced work performance.

Design of displays, hand control, typography, and readability, layout and composition, Exercises in evaluation of human response to product interface, product safety and product liability, Design consideration for appearance, color, texture and forms.

Essential Readings:

1. J. Dul, Ergonomics for Beginners, Taylor & Francis, 2008
Supplementary Readings:

2. D. C. Alexander, Applied Ergonomics, Taylor & Francis, 2005

<table>
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</thead>
<tbody>
<tr>
<td>ID-3207</td>
<td>Geometric &amp; Solid Modelling</td>
<td>4 [3-1-0]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>


Surfaces: Parametric Surfaces, Tangent and Twist Vectors, Reparameterization, Plane Surface, 16-point form, 4 curve form surface, Ruled Surface, Surface of Revolution, Tabulated Cylinder, Lofted Surface, Bicubic Surface, Bezier, B-spline Surfaces, Coons Patch, Offset Surface, Rational Surface.


Essential Readings:


Supplementary Readings:


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</thead>
<tbody>
<tr>
<td>ID-3207</td>
<td>Embodiment Design</td>
<td>3 [3-0-0]</td>
<td>Prof. D.P. Jena</td>
</tr>
</tbody>
</table>


Essential Readings:

Supplementary Readings:

1. Lau Langeveld, Product Design with Embodiment Design as a New Perspective, Delft University of Technology.

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</thead>
<tbody>
<tr>
<td>ID-3302</td>
<td>Instrumentation and Control</td>
<td>3 [3-0-0]</td>
<td>Prof. BBVL Deepak</td>
</tr>
</tbody>
</table>

Introduction to measurement systems- Architecture & Classification, Performance terminology, Errors in measurement, Calibration, Light emitting diode, Light crystal display; Displacement measurement systems- LVDT, RVDT, Resolver, Potentiometer; Velocity & Motion measurement system- Tachogenerators, Gyroscope, Stroboscope; Acceleration measurement systems- Selection & Calibration of accelerometers; Mass, Force & Torque measurement systems- Load cells, Spring balance, Optical torque measurement, force & torque calibration; Temperature measurement systems- Thermocouples, RTDs, Thermometers; Pressure measurement systems- Manometers, Low pressure measurement, High pressure measurement, Calibration of pressure sensors; Flow measurement systems- Obstruction type meter, Rotameter, Turbine flow meter; Level measurement systems- Float systems, Ultrasonic level gauge, Radar; Data acquisition systems- Objectives, Analog system, Digital system, Digital to Analog converter.

Essential Readings:


Supplementary Readings:

5. D. P. Eckman, Industrial Instrumentation, Wiley Eastern Ltd.

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<tbody>
<tr>
<td>ID-3303</td>
<td>Industrial Mechatronics</td>
<td>3 [3-0-0]</td>
<td>Prof. BBVL Deepak</td>
</tr>
</tbody>
</table>

Introduction- Definition, Approach of integration, Elements of Mechatronics, Systems in Mechatronics, Need and application; Sensors & Transducers- Classification, Static and dynamic performance characteristics, Position and proximity sensors, Contact & non-contact type speed measurement systems, Seismic sensors, Piezoelectric and Potentiometric accelerometers, Strain Gauge, Capsules, Bellows and Bourdon tube pressure gauge; Mechanical Actuation Systems- Types of motion, Kinematic chains, Cams, Gear trains, Belt & Chain drives; Electric actuation systems- Classification, Solid-state switches, Solenoids, D.C
motors, A.C motors, Stepper motors; Pneumatic/ Hydraulic Actuation Systems- Directional control valve, Pressure control valve cylinders; Microprocessors, Micro-controllers, Programming & Application; Case Studies- CNC Machines, Automatic washing machine, Automatic camera, Engine magnet systems, Anti-lock braking system, Robotic arm.

**Essential Readings:**

**Supplementary Readings:**
2. Ganesh S Hedge, Mechatronics, Jones & Bartlett Learning, 2010

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<th>Credit</th>
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<tbody>
<tr>
<td>ID-3304</td>
<td>Industrial Robotics</td>
<td>3 [3-0-0]</td>
<td>Prof. BBVL Deepak</td>
</tr>
</tbody>
</table>

Introduction- Definition, Need and application, Robot architecture, Classification and Robot anatomy; Transformations- Position, Orientation and Coordination systems, Rotational transformation, Homogeneous transformation, Composite rotational and homogenous transformation; Kinematics- Concept of degree of freedom, Kinematic parameters, D-H Representation, Arm equation for 4-Axis, 5-Axis and 6-Axis manipulators, Inverse kinematics through solving arm equation; Dynamics- Lagrange’s Equation, Lagrange’s –Euler Model, Dynamic Model of 2 Axis and 3-Axis Robot Manipulators; Trajectory Generation- Joint space schemes, Cubic polynomials, High order polynomial; Sensors Used in Robots- Vision, Range, Proximity, Tactile and Force Sensors, Time of flight and triangulation concepts for object detection; Actuators Used in Robots- Translational and Rotational actuators, Servo systems; Robot Programming: Point to point and continuous motion control strategies, path planning for robot navigation, Pick & Place applications.

**Essential Readings:**

**Supplementary Readings:**

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<tbody>
<tr>
<td>ID-3701</td>
<td>Design Workshop-III</td>
<td>2 [0-0-3]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>
The purpose of this lab is to let the students develop the ability to work on surface / solid modeling softwares like Solid works, CATIA, etc. Related design projects in collaborative groups or on individual basis will work on a topic formulated by the concerned faculty member. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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<tbody>
<tr>
<td>ID-3702</td>
<td>Ergonomics Laboratory</td>
<td>1 [0-0-2]</td>
<td>Prof. Mohit Lal</td>
</tr>
</tbody>
</table>

Study of various anthropometric tools available for anthropometry measurement. Perform an experiment to measure and analyse static anthropometry for standing and sitting positions, arm forward reach, standing erect and flexion / extension, hand anthropometry measurement and analysis, experiment to measure hand strength and pain pressure threshold, muscle strain / stress during extended hand reach activities, objective data collection and analysis during hand drilling operation, study of human modelling and simulation tool kit in JACK (CAD) environment, perform lower back analysis during general seating in JACK environment, postural analysis during various tasks like hand drilling, driving, gait record during walking, etc.

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<tbody>
<tr>
<td>ID-3704</td>
<td>Product Design &amp; Development Laboratory</td>
<td>1 [0-0-2]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>

The purpose of this laboratory is to let the students design the objects in software and develop the models or prototypes using clay, wood or other materials of their own creative designed products. Related design projects in collaborative groups or on individual basis will work on a topic formulated by the concerned faculty member. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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<tbody>
<tr>
<td>ID-3706</td>
<td>Design Practice-II</td>
<td>1 [0-0-2]</td>
<td>Prof. Mohit Lal</td>
</tr>
</tbody>
</table>

Prototype/Model development using thermocol, wood, POP, M seal. Creative design/art work on paper (Origami, Kirigami, Collage), with waste material. Study of various anthropometric tools available for anthropometry measurement. Perform an experiment to measure and analyse static anthropometry for standing and sitting positions, arm forward reach, standing erect and flexion / extension, hand anthropometry measurement and analysis, experiment to measure hand strength and pain pressure threshold, muscle strain / stress during extended hand reach activities, objective data collection and analysis during hand drilling operation.

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<tbody>
<tr>
<td>ID-3801</td>
<td>Industrial Design Project-I</td>
<td>2 [0-0-2]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>

An independent or in Groups of 2-3 students project with one of the following focus: Design project of student interest and / or faculty interest and / or industry project. Re-design project that relooks at an existing problem or situation. Research project, delving into methodological or pedagogic issues. Exploration project, exploring application possibilities in a new technology.
or medium or variations. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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<tbody>
<tr>
<td>ID-3802</td>
<td>Industrial Design Project-II</td>
<td>2 [0-0-2]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>

This project could be an extension of the previous project (if the scope of the project justifies the extension) or it could be an independent project with one of the following focus: Design project of student interest and/or faculty interest and/or industry project. Re-design project that relooks at an existing problem or situation. Research project, delving into methodological or pedagogic issues. Exploration project, exploring application possibilities in a new technology or medium or variations. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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<tbody>
<tr>
<td>ID-4101</td>
<td>Visual Design</td>
<td>3 [3-0-0]</td>
<td>Prof. D.S. Bisht</td>
</tr>
</tbody>
</table>

This Understanding of the factors that directly or indirectly influence the visual design problem. Theory and application of problem structuring methods used in design. Design methodology: Study in the phases of process from analysis through synthesis and evaluation. Program for investigation of problem. Developing questionnaires, interviewing users and selection of suitable techniques to study user behaviors and reactions. Understanding of users demands and manufacturing constraints. Documenting and interpreting of data and formulating conclusions. Role of creativity, role playing, brainstorming, metamorphic thinking and other methods of idea generation. Comparative study in other creative fields. Visual Design methodology for various stages of design process – research, analysis, ideation, concepts, prototyping and evaluation. Methods of data analysis, cross mappings, insights and problem identification. Role of creativity, role playing, brainstorming, body storming, metamorphic thinking and other methods of concept generation.

**Essential Readings:**


**Supplementary Readings:**


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<tr>
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<tbody>
<tr>
<td>ID-4102</td>
<td>Photo Communication</td>
<td>3 [3-0-0]</td>
<td>Prof. D.S. Bisht</td>
</tr>
</tbody>
</table>


**Essential Readings:**


**Supplementary Readings:**

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<tbody>
<tr>
<td>ID-4201</td>
<td>Sustainable Design</td>
<td>3 [3-0-0]</td>
<td>Prof. D.P. Jena</td>
</tr>
</tbody>
</table>

Introduction: Sustainability in design, Sustainable development and system discontinuity: Sustainable development, The sustainability dimensions, Sustainability: Demand for radical change, Sustainability within a context in strong evolution, The diverse paths towards sustainability, Product-Service System (PSS) design for sustainability: Definition, Approaches and skills, Design criteria for system eco-efficiency, Design criteria for social equity and cohesion, Methods and tools for system design for sustainability: Criteria, methods and tools, Modular method for system design for sustainability, Design tools for (System Design for Sustainability) SDS.

**Essential Readings:**

**Supplementary Readings:**

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</thead>
<tbody>
<tr>
<td>ID-4204</td>
<td>Sysyem Design for Sustainability</td>
<td>3 [3-0-0]</td>
<td>Prof. D.P. Jena</td>
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**Essential Readings:**

**Supplementary Readings:**


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</thead>
<tbody>
<tr>
<td>ID-4301</td>
<td>Computer Aided Manufacturing</td>
<td>3 [3-0]</td>
<td>Prof. BBVL Deepak</td>
</tr>
</tbody>
</table>

Introduction to computer aided design, computer aided manufacturing, computer integrated manufacturing, computer aided engineering; CAM- Hierarchy, elements and application; Group Technology- classification, organization and implementation; CAD to CAM; computer aided process planning- CAPP systems, applications and case studies; Introduction to Numerical Control (NC) technology, current status of NC, Influence of NC in design & manufacturing, computer aided NC programming in APT language; Robot Technology-structure and operations, specifications, robot sensors & programming; Flexible manufacturing system- Building blocks of FMS, Machining systems of FMS, Tool management and work piece handling, FMS Control, CAD/CAM Application- Computer Aided Assembly Planning, Computer Aided Inspection;

**Essential Readings:**

**Supplementary Readings:**

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</thead>
<tbody>
<tr>
<td>ID-4302</td>
<td>Design Management</td>
<td>3 [3-0]</td>
<td>Prof. D.P. Jena</td>
</tr>
</tbody>
</table>

Design as a strategic tool in the corporate sector. Design strategy formulation. Case studies in event, brand, and advertisement management. Product management. Introduction to marketing and consumer behavior. Organization, structure and functioning. Interactive role of Design including administration. Design documentation and management of processes such as ISO 9000, ISO 14000, Quality Function Deployment etc. Creativity, innovation and its management in a team work. Team building, interpersonal relationship and conflict resolution. Professional practice, contracts, fees, negotiations, ethics and public relations, project planning.

**Essential Readings:**

**Supplementary Readings:**
2. Design Management Journal of DMI, USA.

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<tbody>
<tr>
<td>ID-4303</td>
<td>Industrial Automation</td>
<td>3 [3-0-0]</td>
<td>Prof. BBVL Deepak</td>
</tr>
</tbody>
</table>

Architecture of Industrial Automation Systems, Measurement Systems Characteristics, Errors & Calibration, Motion Sensing, Signal Conditioning; Process Control- Mathematical Modelling, Time Delay Systems and Inverse Response Systems, PID Control Tuning, Feedforward and Ratio Control. Programmable Logic Control Systems- Sequence/Logic Control, Simple programs for process control based on relay ladder logic, Sequential Function Charts, Hardware modelling; CNC Machines- Interpolation, Control and Drives; Control valves- Single-seated and double-seated valves, Directional control valves; Industrial hydraulic circuits; Supervisory Control and Data Acquisition System (SCADA), Human Machine Interface (HMI); Need for networks in industrial plants, hierarchy and structure of networking, RS 232 based network, Ethernet, TCP/IP, MAP/TOP, Introduction to factory automation and integration.

Essential Readings:

Supplementary Readings:

<table>
<thead>
<tr>
<th>Sub. Code.</th>
<th>Course Name</th>
<th>Credit</th>
<th>Course Caretaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>ID-4304</td>
<td>Rapid Product Development</td>
<td>3 [3-0-0]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>


Essential Readings:

Supplementary Readings:
DFM Approach, Selection and Substitution of Materials: Introduction to DFMA, History of DFMA, steps for applying DFMA during product design, Advantages of applying DFMA during product design, Reasons for not implementing DFMA, DFM approach, DFM guidelines, standardization, comparison of materials on cost basis, design for assembly, DFA index, Poke – Yoke principle; Geometric Dimensioning and Tolerance: Introduction to GD & T, ASME Y 14. 5 standards. Examples for application of geometric tolerances. True Position Theory - Comparison between co-ordinate and convention method of feature location, tolerance and true position tolerance, virtual size concept, floating and fixed fasteners, projected tolerance zone, zero true position tolerance, functional gauges, paper layout gauging, compound assembly, examples; Tolerance Analysis: Process capability, process capability metrics, Cp, Cpk, cost aspects, feature tolerances, surface finish, review of relationship between attainable tolerance grades and different machining process, cumulative effect of tolerances, sure fit law, normal law and truncated normal law, obtainable tolerances in axial dimensions for various machining operations; Selective Assembly: Interchangeable and selective assembly, deciding the number of groups-model-I: group tolerances of mating parts equal; model-II: total and group tolerances of shaft, control of axial play-introducing secondary machining operations, laminated shims, examples; Datum Systems: Degrees of freedom, grouped datum systems-different types, two and three mutually perpendicular grouped datum planes, grouped datum system with spigot and recess, pin and hole, grouped datum system with spigot and recess pair and tongue-slot pair-computation of translational and rotational accuracy, geometric analysis and applications; Form Design of Castings and Weldment: Redesign of castings based on parting line considerations, minimizing core requirements, redesigning cast members using weldment, use of welding symbols, design of weldment; Tolerance Charting Technique: Operation sequence for typical shaft type of components, preparation of process drawings for different operations, tolerance worksheets and centrality analysis, examples, design features to facilitate machining, datum features - functional and manufacturing, component design-machining considerations, redesign for manufacture, examples.

Essential Readings:

Supplementary Readings:
Investigations and study of visual, functional and ergonomic requirements of control and display interfaces. Legibility of display elements, character of different typefaces and their readability, Study of the process of building interactions, User Centered Design Process, Activity Analysis, Structuring of Content, Participatory Design, Experiential Ideation, Scenario Building, Linear and Animatic Storyboarding, Soft Physical Prototyping Techniques.

**Essential Readings:**


**Supplementary Readings:**


**Sub. Code.** | **Course Name** | **Credit** | **Course Caretaker**  
--- | --- | --- | ---  
ID-4702 | Creative Automation Laboratory | 2 [0-0-3] | Prof. BBVL Deepak  

Experiment 1: Introduction to Flexible automation system (MAPS)  
Experiment 2: Study of the various modules in MAPS  
Experiment 3: Study of the various sensors & actuators used in MAPS  
Experiment 4: Introduction to Robotics and Coordinate systems  
Experiment 5: Introduction to MTAB QUEST 4-axis SCARA robot and its programming  
Experiment 6: Programming of MTAB QUEST SCARA robot for pick and place of an object  
Experiment 7: Introduction to 6-axis Aristro robot and its programming  
Experiment 8: Programming in MTAB ARISTRO robot for trajectory generation  
Experiment 9: Introduction to 6-axis Kawasaki RS06L industrial manipulator.  
Experiment 10: Basic introduction to AS language for controlling the Kawasaki RS06L  

**Sub. Code.** | **Course Name** | **Credit** | **Course Caretaker**  
--- | --- | --- | ---  
ID-4703 | Simulation Laboratory | 2 [0-0-3] | Prof. BBVL Deepak  

Experiment 1: Introduction to Degree of freedom and motions, Kinematic Constraints and inversions of four bar mechanism.  
Experiment 2: Calculation of position, velocity and acceleration of crank-rocker mechanism in CAD environment.  
Experiment 3: Representation of boundary conditions and kinematic constraints in CAD environment.  
Experiment 4: MATLAB program for Kinematic models of parallel manipulator and its simulation in CAD environment.  
Experiment 5: MATLAB program for Kinematic models of serial manipulator and its simulation in CAD environment.  
Experiment 6: Program for dynamic force analysis of slider crank mechanisms in MATLAB  
Experiment 7: Introduction to ANSYS workbench and 2D & 3D modelling.  
Experiment 8: Pre-processing, processing and post-processing in ANSYS  
Experiment 9: Solving of plane stress and plane strain problems in ANSYS
<table>
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<tr>
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<th>Course Name</th>
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<th>Course Caretaker</th>
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</thead>
<tbody>
<tr>
<td>ID-4704</td>
<td>Reverse Engineering and Rapid Manufacturing Laboratory</td>
<td>1 [0-0-2]</td>
<td>Prof. M.R. Khan</td>
</tr>
</tbody>
</table>

Demonstration and exercises on methods of Rapid Prototyping, Rapid Machining and Rapid Pattern Manufacturing. Jobs on Rapid Tooling will be prepared by the students. The purpose of this workshop is to let the students develop the ability to work on Rapid prototyping, Reverse engineering and other CMM machines. Related design projects in collaborative groups or on individual basis will work on a topic formulated by the concerned faculty member. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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<tbody>
<tr>
<td>ID-4705</td>
<td>CAM Laboratory</td>
<td>1 [0-0-2]</td>
<td>Prof. BBVL Deepak</td>
</tr>
</tbody>
</table>

Experiment 1: Introduction to Mastercam software
Experiment 2: Mastercam Workspace representation
Experiment 3: Basic commands of CAD drawing in Mastercam
Experiment 4: Advanced commands of CAD drawing in Mastercam
Experiment 5: Solid Modelling in Mastercam
Experiment 6: G-code and M-code to operate MTAB CNC machines.
Experiment 7: Demonstration about MTAB CNC Turning Centers – FLEXTURN
Experiment 8: Turning operation of workpiece
Experiment 9: Demonstration about CNC Machining Centers – FLEXMILL
Experiment 10: Milling operation of workpiece

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<tbody>
<tr>
<td>ID-4901</td>
<td>Project I</td>
<td>2 [0-0-0]</td>
<td>Prof. M.R.Khan</td>
</tr>
</tbody>
</table>

An independent or in Groups of 2-3 students project with one of the following focus: Design project of student interest and / or faculty interest and / or industry project. Re-design project that relooks at an existing problem or situation. Research project delving into methodological or pedagogic issues. Exploration project, exploring application possibilities in a new technology or medium or variations. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.

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<tbody>
<tr>
<td>ID-4902</td>
<td>Project II</td>
<td>2 [0-0-0]</td>
<td>Prof. M.R.Khan</td>
</tr>
</tbody>
</table>

This project will be an extension of the previous project with one of the following focus: Design project of student interest and / or faculty interest and / or industry project. Re-design project that relooks at an existing problem or situation. Research project delving into methodological or pedagogic issues. Exploration project, exploring application possibilities in a new technology or medium or variations. The project may involve collaboration with students from other specializations, disciplines or institutes or with professionals from the industry.
DEPARTMENT OF MECHANICA ENGINEERING

DETAIL COURSE CONTENTS

**ME 2151 MACHINE DRAWING AND SOLID MODELING** 2 credits [0-0-3]

Drawing to be drawn manually: Projection of solids; Nut & bolt and Fasteners; Cotter joint; Plummer block; Expansion joint; Shaft coupling; Drawing to drawn using drafting software: Fundamentals of AutoCAD Mechanical Desktop, Dimension & annotations; Use of Layers; Working with constraint in dimension; Creating assembly; Axi-symmetrical parts; Creating surface features; Working with bill of material; Free hand sketches of commonly used parts are to be drawn and submitted to the teacher concerned in the sessional class.

Essential Reading:

**ME 3101 DESIGN OF MACHINE ELEMENTS** 3 credits [3-0-0]

Introduction to machine design, methodology, strength, rigidity, fracture, wear, and material considerations in design, use of standards, Selection of materials and processes. Standard numbering system including BIS designations of materials. concept of factor of safety. Application of theories of failure to design. Design of Riveted, Welded, Bolted joints, Power screw, shafts, keys and couplings, belt, rope and chain drives, journal bearing and antifriction bearings, springs, clutches and Gears.

Essential Reading:

**ME 2103 KINEMATICS OF MACHINES** 3 credits [3-0-0]

Mechanisms: Lower and higher pairs, degrees of freedom, various types of mechanisms, their inversions and applications, Kinematics and structure diagrams, equivalent linkages, steering mechanisms. Motion analysis of planer mechanisms by graphical, analytical and computer aided methods instantaneous centre, Corioli’s component of acceleration. ; Cams: Cam follower systems, synthesis of roller cams, cam profiles, pressure angles, ; Gears: Gearing terminology, spur, bevel, helical, worm, gears, motion and synthesis of simple, reverted and epicyclic gear trains, gear corrections. ; Kinematic synthesis: Classical synthesis techniques, Analytical synthesis of four line mechanisms and planner mechanisms. Dimensional synthesis, three position synthesis for function generation, path generation.

Essential Reading:
ME 2101 MECHANICS OF SOLIDS


Essential Reading:

Supplementary Reading:
2. G.H.Ryder, Strength of Materials - ELBS.

ME 2202 PRIMARY PRODUCTION PROCESSES


Essential Reading:
1. Manufacturing Technology, P. N. Rao, TMH

Essential Reading:

Supplementary Reading:
1. J.P.Holman, Heat Transfer, TMH, ND 2015

ME 2301 ENGINEERING THERMODYNAMICS 3 credits [3-0-0]

Basic concepts, thermodynamic equilibrium and quasi-static processes, Zeroth law of thermodynamics; Energy Interactions: displacement and other types of work, free expansion, Heat transfer; First Law of Thermodynamics: First law for a closed system, Energy - a property of the system, Different forms of stored energy, enthalpy, First law applied to flow processes; Second Law of Thermodynamics: Qualitative difference between heat and work, Heat Engines, Refrigerators and Heat pumps, Kelvin-Plank and Clausius statements of second law and their equivalence, Reversibility and irreversibility, Ideal processes, Carnot Cycle, Corollaries of second law, Carnot's theorem, Absolute thermodynamic temperature scale, Clausius inequality; Entropy: Definition, Principles of increase of entropy, calculation entropy for various processes; Available Energy and Availability: Helmholtz and Gibbs functions, Availability in steady flow, Entropy equation for flow processes, irreversibility; Properties of Pure Substances: p-V, p-T, T-s and h-s diagrams for a pure substance, quality, Steam Tables and charts for thermodynamics properties, Measurement of steam quality; Properties of Gases and Gas Mixtures: equation of state, Calculation of property changes for ideal gases, Real gases definition and equations of state, Law of corresponding states, Gas mixtures and Dalton's Law; Combined 1st and 2nd Laws: Maxwell relations, T-dS equations, Joule-Kelvin effect, Clausius-Clapeyron equation, Gibb's Phase rule and Conditions of stability; Reciprocating air compressors: Work required for single and multistage air compressors, Effect of intercooling, Optimum interstage pressure, Effect of clearance on volumetric efficiency, Air motors.

Essential Reading:
ME 4304  RENEWABLE ENERGY  3 credits [3-0-0]


Essential Reading:

Supplementary Reading:

WS 2150  ADVANCED MANUFACTURING PRACTICE  2 credits [0-0-3]

CNC Milling, Turning, Machining of Gears, Fabrication of structure

ME 2152  MECHANICS OF SOLIDS LAB.  1 credits [0-0-2]

Tensile, compressive and shear tests, Load-displacement, Stress-strain diagram, Rotational fatigue tests, Impact test, Hardness measurement, Formability

ME 3151  MACHINE ELEMENT DESIGN PRACTICE  2 credits [0-0-3]

Design and drawing of boiler (pressure vessels) ; Design and drawing of bolted joints ; Design and drawing of welded joint ; Design and drawing of cotter and knuckle joint ; Design and drawing of flexible coupling ; Design and drawing of universal coupling ; Design and drawing of screw jack ; Design and drawing of belt/chain drive ; Design and drawing of fly wheels ; Design and drawing of cams. Design of clutches ; Design of spur gears ; Design of spiral and bevel gears ; Design of crank, piston and cylinders ; Design of connecting rods, crank shafts

ME 5101  FINITE ELEMENT METHOD  3 credits [3-0-0]

Introduction, brief history of development, advantages, disadvantages of finite element analysis, basic steps and limitations, error and accuracy in finite element analysis, structural stiffness and network analysis, assembly and analysis of a structure, finite
element analysis of an elastic continuum, displacement approach, minimization of total potential energy, convergence criteria, generalization of finite element concepts, alternative approach to finite element formulation, plane stress and plane strain analysis, element characteristics, triangular, rectangular and isoparametric elements, some practical applications, axisymmetric stress analysis, some illustrative examples, computer methods and computer programmes, data input, stiffness generation, assembly and solution of equations and output of results, application of FEM to structural, plastic deformation, fluid flow and heat transfer problems, FEM software packages, modeling capabilities, preprocessors and postprocessors, modern trends in finite element analysis.

Essential Reading:

Supplementary Reading:

ME 3106 COMPOSITE MATERIALS 3 credits [3-0-0]


Essential Reading:
3. Dr N. Chand, Tribology of Natural fiber Composites, Wood Head Publishing Limited, England

ME 3202 METAL CUTTING AND TOOL DESIGN 3 credits [3-0-0]

Geometrical parameters of cutting tool edges and their effect on tool force and power consumption, Mechanics of chip formation at low and high cutting speeds. Orthogonal and oblique cutting ; Controlled contact cutting, Shear angles, Force and velocity relationships, Cutting forces in turning ; Planning, Drilling and milling operations, controlled Contact Cutting, Chip-Breaking Effect, stress-distribution ; Types of Tool Wear: Flank wear, Crater wear, Wear measurement, Cutting fluid and its effect ; Machinability Criteria, Tool life and Taylor’s equation, Effect of variables on tool life, and surface finish, Tool-life test ; Economics of Machining, Economic tool life, Gilbert’s Model. ; Introduction to cutting tool materials, types of cutting tools, design of single point cutting tool, form tool, broach ; Introduction to micro-machining, diamond turning, micro-turning, micro-drilling, micro-milling, hybrid-micromachining, micro-edm, micro-ecm, micro-wedm, micro-wedg ; Sheet-metal working, blanking and piercing, compound and progressive die ; Principles of location and clamping, design of drilling
jig and fixture for milling, broaching, turning; Design of forging die block, drop forging and upsetting.

Essential Reading:

Supplementary Reading:
1. Arshinov, *Metal cutting Theory Design* - Mir Publisher

**ME 3201 METAL MACHINING AND AUTOMATION** 3 credits [3-0-0]


Essential Reading:
2. *Production Technology* – HMT-TMH.

Supplementary Reading:
1. Radhakrishnan & Subramanium, *CAD, CAM, CIM* - New Age India Publisher Pvt., Ltd.

**ME 4210 ADVANCED MANUFACTURING TECHNIQUES** 3 credits [3-0-0]

Surface engineering and High speed grinding: Application of advanced coatings in high performance cutting tools and high performance super-abrasive grinding wheels. Application of surface coating in metal-ceramic joining. Ultra high speed grinding with monolayer CBN grinding wheel. Machining and grinding under cryogenic environment. Micro and nano machining of glasses and ceramics in ductile regime using diamond
cutting tool and diamond grinding wheel. Theory and application of chemical processing: Chemical Machining, Aching of semi conductors, Coating and Electroless forming and CVD. Rapid prototyping: Need for Rapid Prototyping, Basic Principles and advantages of RP, Classifications of different RP techniques with examples, Introduction to three Representative RP techniques: Fused deposition; modeling, Laminated Object Manufacturing and Stereo-lithography. MEMS: Introduction, history, development and need of micro-electro-mechanical systems. IC fabrication processes used for MEMS; MEMS sensors and actuators; Mechanical Process techniques and process models for micro-machining; Fabrication processes and design of the process sequences; Agile prototyping; Reliability and process control of micro manufacturing processes. Introduction to nano-technology processes. Concurrent Engineering: Product development cycle, Sequential Engineering versus Concurrent Engineering, Implementation of Concurrent Engineering, Concurrent Engineering and Information Technology, Soft and Hard Prototyping, Characteristics of Concurrent Engineering Key factors influencing the success of CE.

Essential Reading:

ME 4201 METROLOGY, QUALITY CONTROL AND RELIABILITY

METROLOGY: Line and End Standards, Principles of Measurements, Calibration, Accuracy and Precision; Measurement of Surface Roughness, Screw, Thread and Gears; Limits, Fits and Gauges, Assembly by full, partial and group interchangeability, geometric tolerances;
QUALITY ASSURANCE: Some useful Probability Distribution, Testing of hypothesis, type I and type II errors, central limit theorem. Taguchi’s Loss function, Orthogonal Arrays, Linear Graphs, parametric design, signal-to-noise Ratio, ANOVA. Causes of Variation, standard error of mean, process capability, PCR, Natural tolerance Limits, Specification Limits, Trial and Revised control Limits, Rational subgroups, Control charts for variables (X-bar, R), Control charts for fraction non-conforming, control charts for non-conformation. Design of single & Double sampling plan. OC curve, AOQ, AOQL, ATI, ASN; MIL-STD 105D tables, switching rules.
RELIABILITY: Definition, bath-tub-curve, system reliability, reliability improvement, maintainability and availability, Life tests, Acceptance sampling plan based on life tests.

Essential Reading:

ME 4104 SURFACE ENGINEERING

Philosophy of surface engineering, general applications and requirements; Corrosion Processes: Basic principles of electrochemistry and aqueous corrosion processes; pitting, crevice and exfoliation corrosion; influence of deposits and anaerobic conditions; corrosion control; high temperature oxidation and hot corrosion; corrosion/mechanical property interactions; Friction and Wear: Abrasive, erosive and sliding wear. The interaction between wear and corrosion; Analytical Techniques: X-ray diffraction, TEM, SEM and WDP analysis, surface analysis by other techniques; Surface Engineering: Philosophy; surface engineering as part of a manufacturing process; integrating coating systems into the design process; Coating Manufacture:
Electro deposition; flame and plasma spraying; physical vapor deposition; chemical vapor deposition; surface treatments; paint and paint systems; Applications: Coating systems for corrosion and wear protection; new coating concepts including multi-layer structures, functionally gradient materials, intermetallic barrier coatings and thermal barrier coatings.

Essential Reading:
3. Howard E. Boyer (Editor), Case Hardening of Steel, ASM International, Metals Park, OH 44073.

ME 3301 HEAT TRANSFER 3 credits [3-0-0]


Essential Reading:
1. Heat Transfer By P.S. Ghoshdastidar, Oxford University Press
2. Heat Transfer By J.P. Holman, McGraw Hill Higher Education

ME 2302 FLUID MECHANICS 3 credits [3-0-0]

Introduction: Definition of fluid, Concept of shear stress, Concept of continuum; Properties of fluids; Classification (like Ideal and Real fluids, Newtonian and Non-Newtonian fluids, Internal versus External Flow, Compressible versus Incompressible Flow, Laminar versus Turbulent Flow, Natural versus Forced Flow, Steady versus Unsteady Flow, One-, Two-, and Three-Dimensional Flows, etc.). Fluid Statics: Pressure at a point, Pascal’s law, Variation of pressure within a static fluid – equation of
hydrostatic pressure distribution, Variation of properties in static atmosphere; Measurement of pressure; Hydrostatic thrust on plane and curved surfaces; Buoyancy, Stability of submerged and floating bodies; Fluid masses subjected to uniform accelerations. Fluid Kinematics: Eulerian and Lagrangian description of fluid flow, Velocity and acceleration of fluid particles; Stream line, Streak line and path line, stream tube, Equation of continuity for a stream tube; Deformation of a fluid element – linear and angular deformation and rotation, Vortex motion- irrotational flow; Pressure and stress tensor; Stream function and velocity potential. Fluid Dynamics: Principle of conservation of mass and momentum, Stokes law of viscosity and Navier-Stokes equations – some exact solutions; Inviscid flow – Euler equation, Derivation of Bernoulli’s equation and physical significance of different terms, Applications of Bernoulli’s equation; Characteristics Of Laminar & Turbulent Flow: Reynolds experiment, critical Reynolds number; Laminar flow through pipe – Hagen Poiseuille equation. Flow Through Closed Conduits: Darcy Weisbach equation, Friction factor, Moody’s diagram; Minority losses – at sudden expansion, contraction, at bends, at valves and fittings, etc.

Essential Reading:
2. B. S. Massey, Mechanics of Fluids, ELBS.

Supplementary Reading:
1. R. K. Bansal, Fluid Mechanics, Laxmi Publications (P) Ltd.
4. K. L. Kumar, Fluid Mechanics, S. Chand Co.

ME 3303 FLUID DYNAMICS & HYDRAULIC MACHINES 3 credits [3-0-0]

Boundary Layer Theory: Flow over a flat plate, Concept of boundary layer, Growth of boundary layer, Boundary layer thickness, Laminar and turbulent boundary layer, Boundary layer equation, Boundary layer approximation, Similarity variable & similarity solution (Blasius solution), Von Karman’s momentum integral method, Skin friction drag coefficient; Boundary layer in pipe flow; Separation of boundary layer, form drag; Lift and drag on submerged bodies, aerofoils. Ideal Fluid Flow: Unsteady Bernoulli’s equation; Solution of Laplace’s equation by separation of variables – lid driven flow in a square cavity; Velocity potential and stream function, Flownet, Introduction of complex potential; Simple 2D irrotational uniform flow, plane source, plane sink, combination of source and sink, doublet, superimposition of uniform flow and doublet; Dimensional Analysis & Similarity: Dimensional analysis and Buckingham Pi theorem; Similarity and model studies. Hydraulic Turbines: Classification, Pelton, Francis and Kaplan turbines, Blade angle, Velocity triangle, Efficiencies. Specific speed, Performances of turbines. Centrifugal Pumps: Principle and classification, Multi stage pumps, Pumps in series and parallel, Blade angle, Velocity triangle, Efficiency, Specific speed, Characteristic curves, Cavitation in pumps, NPSH. Reciprocating Pump: Working principle, Slip, Work done, Effect of acceleration and frictional resistance, Separation, Air vessels.

Essential Reading:
2. B. S. Massey, Mechanics of Fluids, ELBS.

Supplementary Reading:
ME 3302  I.C. ENGINES AND GAS TURBINES  3 credits [3-0-0]


Essential Reading:

ME 4303  REFRIGERATION AND AIR-CONDITIONING  3 credits [3-0-0]


Essential Reading:
1. C.P.Arora, A Course in Refrigeration and Air-conditioning, Tata Mc. Graw-Hill
Supplementary Reading:
1. W.F. Stoecker, *Refrigeration and Air Conditioning* - TMH.

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**ME 4306 AIRCRAFT AND ROCKET PROPULSION** 3 credits [3-0-0]


Essential Reading:

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**ME 3306 TURBOMACHINERY** 3 credits [3-0-0]

Ideal and actual velocity triangles, Slip and its estimation, Impulse and reaction type machines, Degree of reaction, Effect of outlet blade angle on blade shape, Model laws, Specific speed and shape number, Special features of hydro, steam and gas turbines, Performance characteristics of turbo-machines; Axial flow compressors: Flow through cascades, cascade terminology, flow separation, radial equilibrium theory, actuator disc theory, effect of tip clearance, secondary flow, performance characteristics, surging and stalling; Axial flow turbine: Vortex theory, blade design, cooling of turbine blades, performance characteristics, profile loss, secondary flow loss, annulus loss, tip clearance, limiting factors in turbine design; Applications: Hydel power plant, Steam power plant, Gas turbine power plant, Aircraft propulsion.

Essential Reading:
4. S.M. Yahya, *Turbines, Compressors and Fans*, TMH.

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**ME 4307 GAS DYNAMICS** 3 credits [3-0-0]

Energy equation for a flow process, Stagnation values, various regions of flow, critical velocity of sound, Crocco number, Effect of Mach number on compressibility, rate equations of momentum energy and entropy; Isentropic flow with variable area: Mach number variation, Stagnation and critical states, Area ratio as a function of Mach number, Impulse function, Mass flow rate, Flow through nozzles and diffusers, use of gas tables; Wave motion: Wave propagation in elastic solid medium, Propagation of...
sound waves, pressure field due to a moving source of disturbance, Mach angle; Flow with normal shock waves: Governing equation, variation of Mach number, Static Pressure, temperature and density etc. across the shock, Strength of a shock wave, Moving shock waves; Flow in constant area ducts with friction: The Fanno curves, Fanno flow equations and solutions, variation of flow properties, tables and charts for Fanno flow; Flow in constant area ducts with heat transfer: The Rayleigh lines, Fundamental equations, Rayleigh flow relations, Variation of flow properties, Maximum heat transfer, Tables and charts of Rayleigh flow; Jet propulsion: Thrust equation, maximum thrust relationship, Engine performance parameters, Ram Jet engine, ideal ram jet, ideal and actual turbojet engines; Rocket propulsion: Operating principle, thrust equation, specific impulse, jet velocity, thrust coefficient, characteristic velocity, impulse weight ratio.

Essential Reading:

### ME 4353 HEAT TRANSFER AND REFRIGERATION LAB.

To find overall heat transfer coefficient of a double pipe heat exchanger; To develop a correlation for natural convection of air around a vertical cylinder; To study the boiling heat transfer phenomena and determination of CHF for pool boiling of water; Measurement of thermal conductivity of solid by guarded hot plate method; To determine the efficiency of a pin-fin in natural and forced convection; To find the heat transfer coefficient in forced convection of air in a tube; COP and Tonnage capacity of room air-conditioner; Performance study of vapour compression refrigeration test rig; Determination of COP and tonnage capacity of ammonia ice plant; Performance study of absorption refrigeration test rig; Performane study on LN$_2$ Cryo-plant; Performane study on Pulse tube refrigerator.

### ME 4354 AIR CONDITIONING AND CRYOGENIC ENGG. LAB.

COP and Tonnage capacity of air-conditioner plant; Performane study on LN$_2$ Cryo-plant; Performane study on Pulse tube refrigerator.

### ME 3351 FLUID MECHANICS AND FLUID MACHINERY LAB.

Verifications of momentum equation; Verifications of stokes apparatus; Calibration of Venturimeter; Verifications of Bernoulli’s equation through a convergent and divergent
passage; Study of Major losses in Pipes; Study of Minor losses in Pipes; Velocity distribution in a pipe flow; Velocity distribution in open channel flow; Variable and constant speed characteristics of Pelton turbine; Performance characteristics of Francis Turbine; Performance characteristics of Kaplan Turbine; Constant discharge and constant speed characteristics of centrifugal pump; Pressure characteristics of a centrifugal blower; Determination of air power, static and overall efficiency of a fan at constant speed; Pressure characteristics of axial flow compressor; Study of simple/compound impulse and reaction steam turbines; Thermal efficiency of steam turbine; Performance study of screw compressor.

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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits (L-T-P)</th>
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<tbody>
<tr>
<td>ME 3251</td>
<td>PRODUCTION ENGG. LAB.</td>
<td>1 credits [0-0-2]</td>
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<tr>
<td>ME 4351</td>
<td>COMPUTATIONAL FLUID DYNAMICS LAB.</td>
<td>2 credits [0-0-3]</td>
</tr>
<tr>
<td>ME 3352</td>
<td>IC ENGINES LAB.</td>
<td>2 credits [0-0-3]</td>
</tr>
<tr>
<td>ME 3252</td>
<td>PRODUCTION ENGINEERING PROJECT</td>
<td>1 credits [0-0-2]</td>
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</tbody>
</table>

Calibration of slip gauge using interference of light by Interference Method; Internal taper and bore measurement using two precision spheres; External taper measurement by sine center; Bulge test of thin Aluminum blank in to a dome by hydraulic pressure and study it's forming characteristics; Calibration of linear variable differential transformer (LVDT); Measurement of screw parameters by floating carriage machine; Measurement of tool angles of a single point cutting tool; Metrology of an external screw thread by “Tool maker’s Microscope”; Experiment on machining in machining center (CNC); Condition monitoring in machining processes using acoustic emission; Experiments on Ultra Sonic Machining; Experiments on Electro Discharge Machining; Experiments and demonstration of Laser Machining; Experiments and demonstration of Electro Chemical Machining process; Experiments and demonstration of Abrasive Jet Machining; Programming on various CNC machine tools and use of CIM

CFD analysis for fluid flow problem with heat transfer over a flat plate; CFD analysis for fluid flow problem with heat transfer through a circular tube; Design of a thermal system: Thermal Power Plant; Calculation of heating/cooling load for a conditioned space; Second law analysis for a heat exchanger; FDM application to high velocity flow with upwinding; FDM application to simplified Navier-Stokes equation; FEM applied to flow around a cylinder.

Study of Two/Four stroke petrol/diesel engine; Determination of volumetric efficiency of reciprocating air-compressor; Valve timing diagram of four-stroke petrol/diesel engines; Load test on petrol Engine; Load test on diesel engine; Morse test on multi-cylinder petrol/diesel engine; Heat Balance study of petrol/diesel engine; Study of differential and transmission system of automobile; Study of 4-speed/5-speed gear box of automobile; Study of electric circuit and ignition system of automobile; Emission Analysis of I.C. Engines; Variable compression ratio test on I.C. Engines; CFR engines with pressure Vs Crank angle diagram – combustion process and emission control studies; Performance tests on multi-cylinder CI engines with bi-fuel operation & heat recovery system of exhaust gas.

Design and drawing of single point cutting tool for turning operation; Design and drawing of Form tool for mass production of conventional profile generation; Design and drawing of Broach tool for industrial mass production; Design and drawing of metal forming Press tool used in blanking & punching; Design and drawing of Jig & Fixture for mass production in a product focused system; Design and drawing of Gauges used in shop floor dimensional checking; Process planning for manufacturing
by mass; Process planning for manufacturing by order; Tool layout optimization for a capstan lathe/machining center; Design of forging die blocks for mass production; Design and draw of metal forming Press tool used in deep drawing; Computer Aided Design of forging/forming die/cutting tool for optimal function; Conceptual Design of a machine tool with better ergonomics/environment friendly/low cost/less maintenance/less running cost/high precision etc.

**ME 3254 PRODUCT DEVELOPMENT PROJECT**  
1 credits [0-0-2]  
Need analysis, Need statement, Cause-effect diagram, Idea generation, Evaluation, Morphology analysis, SWOT Analysis, Objective tree, Functional tree, Specifications, Modelling, Patent writing

**ME 4110 ADVANCED MECHANICS OF SOLIDS**  
3 credits [3-0-0]  
Elementary concept of Elasticity: Stresses in three dimensional bodies, Equations of equilibrium, Strain displacement relations, Stress strain relations, Compatibility equations, Boundary conditions. Plane stress, Governing differential equation, Airy stress function (Cartesian co-ordinates); Energy Methods: Castigliano's theorems, Maxwell's theorem of Reciprocal relations and Betti's Law, Principle of virtual work, Unit load and unit couple method; Thick Walled Cylinders: Thick cylinders subjected to internal and external fluid pressures, Compound cylinders, Shrink-fit; Unsymmetrical Bending: Properties of beam cross sections, Slope of neutral axis, Stresses and deflections in unsymmetrical bending; Shear Center of thin wall beam cross section; Curved Beams: Bending of beams of large initial curvature, Stress distribution in beams with rectangular, Circular and trapezoidal cross sections, Location of neutral axis, Stresses in crane hooks, Rings and chain links; Membrane stresses in shells, application to cylindrical, Spherical and conical shells; Plastic Analysis of Beams: Plastic Modulus, Shape factor, Plastic hinge, Application to beams, Determination of collapse loads; Advanced Topics in Strength of Materials: Repeated stresses in structural and machine components, Fatigue in metals, Endurance limit, Concept of stress concentration, Stress concentration factor and notch sensitivity; Photoelastic Stress Analysis: Two dimensional photoelastic method of stress analysis, Stress optic law, Plane polariscope, Light and dark fields in a polariscope, Isoclinic and isochromatic fringe patterns.

**Essential Reading:**  

**Supplementary Reading:**  

**ME 4101 MECHANICAL VIBRATION**  
3 credits [3-0-0]  

Essential Reading:

Supplementary reading:

**ME 3102**  
DYNAMICS OF MACHINERY  
3 credits [3-0-0]

Force analysis: Static forces in 4-bar mechanism, slider-crank mechanism, quick-return mechanism, reciprocating engine mechanism with sliding friction. Plane motion of rigid body, inertia forces of a reciprocating engine mechanism, four-bar mechanism, shaking forces and moments, Dynamics of reciprocating engine mechanism (analytical method) and its bearing loads.

Turning moment diagram and flywheel: Fluctuation of crank shaft speed, flywheel in IC engine, punching press, Analytical expression for turning moment.

Balancing: Unbalance in one and several planes, static and dynamic unbalance, balancing machines, field balancing, balancing a single-cylinder and multi-cylinder engines, analytical technique for balancing of multicylinder reciprocating engines, balancing of linkages and machines, V and radial engines, graphical and analytical methods, method of direct and reverse cranks, dynamic balancing machines.

Cam dynamics: Cam profile construction, tangent cam, Analysis of eccentric cam, Analysis of disc cam with roller follower, Gyroscope: Gyroscopic couple - Plane disc, Two bladed air screw, Analysis of the forces on bearings due to the forced precession of rotating disc mounted on shafts, Gyroscopic effects on a two wheel and a four wheel vehicle, Gyroscopic stabilization

Governors and Gyroscopes: Types of governors, performance parameters, Governor effort and power, controlling force, friction and insensitivity, centrifugal effect of revolving arms, gyroscopic forces and couple, Stabilization of 4-wheeled vehicle on curved path and 2-wheeled vehicle taking a turn

Vibration Analysis: Natural frequency, equivalent system, energy method, Free vibration response, damping, single degree of freedom system with viscous damping, Logarithmic decrement, forced vibration, Base excitation, Vibration isolation, bending critical speeds of simple and multi-mass shafts, torsional system.

Essential Reading:
1. S.S. Rattan, *Theory of Machines*, MGH
2. R.K.Bansal, *Theory of Machines*, Luxmi Publisher

Supplementary Reading:
3. AS Hall, *Kinematics & Linkage Design*, PHI

**ME 4105**  
EXPERIMENTAL STRESS ANALYSIS  
3 credits [3-0-0]

Photoelasticity: Light and Optics as Related to Photoelasticity Behavior of Light, Polarized Light, Plane Polarizers., Wave Plates, Arrangement of Optical Elements in a Polariscopic, Constructional Details of Diffused Light and Lens - Type.


Essential Reading:
1. J.W. Dally and W.F. Riley, Experimental Stress Analysis - 2nd Ed. MGH.

Supplementary Reading:
1. Dureli. An Introduction to Experimental Stress and Strain Analysis.
2. Srinath et.al. An Introduction to Experimental Stress Analysis - MGH.

ME 4102 MECHATRONICS 3 credits [3-0-0]
Introduction to Mechatronics Systems, Classification and Description of Mechatronic using Graphical and Block Diagram Method ; Sensors And Transducers: Introduction-Performance Terminology-Displacement, Position and Proximity-Velocity and Motion-Fluid, Classifications of different sensors used in mechatronics systems, Classifications of Actuators, Types of stepper motors and its control circuit, Types of Dc Motor, DC Geared motors, SD Servo geared Motors, Introduction to Micro processors and Micro Controllers used for Mechatronic devices, Introduction to various computational Intelligence techniques used in mechatronics systems, Types of Electric, Pneumatic and Hydraulic Equipment and Control circuit used in Mechatronics System. Data Acquisition system used in Mechatronic Devices, Pick and Place robot, Mechatronics design in Automated car parking system, Automated Washing Machine System, Automated Traffic signal Method, Automated Air Conditioning Method.

Essential Reading:
1. Bolton, Measurements, Addison Wesley.
2. HMT, Mechatronics, TMH

Supplementary Reading:
1. Histand and Aliatore, Introduction to Mechatronics and Measurement system, MGH
2. K. Stither, Design with Microprocessor for Mechanical Engineers, MGH

ME 4103 TRIBOLOGY 3 credits [3-0-0]
rough surfaces, sliding and rolling friction, various laws and theory of friction. Stick-slip friction behavior, frictional heating and temperature rise. Friction measurement techniques. Wear and wear types.
Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques. Introduction to lubrication. Lubrication regimes. Introduction to micro and nano tribology.

Essential Reading:
2. P. Sahoo. Industrial Tribology, Tata Mc Graw Hill

ME 4106 ROBOTICS 3 credits [3-0-0]

Introduction, Automation and Robotics, brief history, Social and economic aspects, Advantages overview of robots and future application; Classification & structure of robotic system: Classification, Configuration, wrist, end effectors, Links, Joints, Drive system; Control System: Basic control system concepts, model, transformation and block diagrams, controllers ON & OFF, transient response; Robot Kinematics: Direct & inverse kinematics, rotation matrix, composite rotation matrix, homogenous transformations, links, joints D-H representation, Geometrical approach of direct & reverse kinematics; Robot Arm dynamics: Joint velocities, KE, PE & motion equation of manipulating trajectory planning, joint interpolated trajectory; Robot Programming: Languages, Graphics, Storing & operating, Task programs; Types of electric, pneumatic and hydraulic system used for robotic application, Description of Sensors used for Robotic Systes, Description of Mobile Robots, Application of various AI methodology to control robots.

1. Groover, Industrial Robot, PHI.

ME 3103 SYSTEM DYNAMICS AND CONTROL 2 credits [2-0-0]

Closed loop and open loop system, design principles of control systems, Laplace transforms method, transfer functions, block diagrams, deriving transfer functions of physical systems, signal flow graphs, proportional, derivation and integral controllers, impulse response functions; First order systems, second order systems, higher order systems, Routh's stability criterion, static and dynamic error coefficients, introduction to system optimization; Root locus plots, root locus analysis of control systems; Logarithmic, polar and log magnitude versus phase plots, Nyquist stability criterion, stability analysis, closed loop frequency response lag, lead compensations; Nonlinear control systems, describing function analysis of nonlinear control systems; Introduction to discrete time systems, state space representation of systems, optional control systems and adaptive control systems.

Essential Reading:
1. K. Ogata, Modern Control Engineering, PHI.

ME 3108 MATERIAL HANDLING 3 credits [3-0-0]

Introduction: Development of Material Handling Technology, Design objectives; Classification and characteristics of materials, Types of industrial transport, classification and working principles of materials handling devices; Cranes: Structural and mechanical design of electrical overhead traveling cranes; Conveyors: Design of
belt, Apron, Screw, Roller, Vibrating and pneumatic conveyors; Elevators: Design of bucket, Arm and swing tray elevators; Steel mill cranes: Working principles and operations of various types of steel mill cranes such as stripper, charger, ladle and soaking pit cranes.

Essential Reading:

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<th>Course Code</th>
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<tbody>
<tr>
<td>ME 4207</td>
<td>DECISION MODELING</td>
<td>3 credits [3-0-0]</td>
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</table>

**Linear Programming** – Formulation and Solution of LPP, Duality, Sensitivity Analysis, Dual Simplex Method, Transportation and Assignment Problem, Goal Programming, Simple Case Studies, Introduction to OR Software package; Production Planning & Control – Short range and Long range Planning, Production Planning, Master Production Schedule, Capacity Planning, Aggregate Planning, GANT Chart Forecasting, Time series, Causal and Predictive Methods, Forecasting using neural network (back propagation algorithm), Scheduling and Sequencing, Flow shop and Job Shop scheduling, Flow shop scheduling using Johnson’s rule, Branch and Bound Technique and Genetic Algorithm; Plant Layout – Types of layout, Design of Functional Layout using CRAFT, ALB Problems, Solution of ALB Problem using heuristics (Largest Candidate Rule, Ranked Positional Weight, Combination of heuristics, and COMSOAL) and Simulated Annealing, Group Technology, Classification and Coding Systems, Solution of GT problems using heuristics viz. ROC-I, ROC-II and MODROC and neural networks (Adaptive Resonance Theory); Plant Location – Introduction to subjective and objective factors, Brown Gibson Model, Multiple Locations, Application of AHP in plant Location; Project Management – Project Network, Critical path, PERT & CPM, Crashing and Resource Leveling; Simulation – Random Variables, Random Number Generation, Simulation of simple Queuing Models, Validation and Data collection; Decision Environment – Decision making under Certainty, Risk and Uncertainty, Decision Tree, Game Theory; Maintenance management - Preventive, Predictive and Corrective maintenance, Determination of Optimum Schedule for Maintenance, Replacement analysis.

Essential Reading:

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<tr>
<td>ME 4601</td>
<td>PROJECT-I</td>
<td>3 credits [0-0-3]</td>
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</table>

Problem Statement, Literature Review, Research Gap, Objective of work, Methodology, Material selection, Design of Experiment, Tooling, Modelling, Validation, Analysis

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<tr>
<td>ME 4602</td>
<td>PROJECT-II</td>
<td>3 credits [0-0-3]</td>
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Conferm experimentation, Result discussion, Dissemination

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<tr>
<td>ME 4204</td>
<td>ADVANCED MANUFACTURING SYSTEMS</td>
<td>3 credits [3-0-0]</td>
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</table>

Definition and broad characteristics of Flexible Manufacturing Cells, Systems, Islands and Flexible transfer lines - Place of flexible manufacturing systems in CIM - The FMS relational: Economics and technological justification for FMS - Design and Planning: the role of associated technologies such as GT, JIT and simulation - Installation, Operation and evaluation - Scheduling problems - FMS hardware CNC machines tools, robots, AGVs, ASRs, Inspection and Cleaning stations - Control aspects of FMS-DNC of machine tools, cutting tools, robots, quality control and inventories - Personnel and

Essential Reading:
2. P. Radhakrishna and V. Raju, CAD, CAM & CIM, New Age, International Publisher.


Essential Reading:

Supplementary Reading:
1. D.F Rogers, Procedural elements for computer graphics, TMH Publisher.

Product life cycle, quality products, evaporative markets, globalization and Concurrent engineering. Review of concurrent engineering techniques like DFM (design for manufacture). DFA (design for assembly), QFD (quality function deployment), RP
(rapid prototyping), TD (total design) for integrating these technologies. Product information systems and their architecture. Information environment for suppliers, management, testing & inspection design engineering, purchasing, process control, manufacturing, support plans, operators, quality control, servicing and maintenance. Product information modeling. Integration of information models and end users applications. Computer aided simultaneous engineering systems. Integrated concurrent design and product development. Constraint networks, created by capacity expansion and professional resource expansion. Case studies, DYNAMO, STELLA and SD based management games.

Essential Reading:

**ME 4208 ENTREPRENEURSHIP**

3 credits [3-0-0]

Enterprise Launching and Resourcing: Environmental Analysis: Entrepreneurial process and enterprise building, environmental scanning & analysis, Institutions and their role, procedures for launching small scale industries, incentives and finances available to SSI units and new entrepreneurs. How to identify and select good business opportunity; Project formulation: Feasibility; industry and firm level feasibility, study of formats of applications of financial institutions, determining project size, investment magnitude and forms of organization, estimation of cost, project scheduling, financial analysis, plant layout; Enterprise Management: Basic management concepts: Functions of management, planning, organizing, directing, controlling, coordinating. Introduction to computers and management information systems, business communication; Personnel management: Work motivation, labor relations, wage administration, incentives etc; Production management: Production, planning and control routing. Scheduling, dispatching, expediting and evaluation. Production scheduling technique, quality control inspection. Standards and specifications – ISI; Financial Management including costing & Accounting practices: Tools of financial analysis, volume, profit analysis, sensitivity analysis, management of working capital, financing of working capital requirements, financial accounting, cost accounting, risk taking and insurance; Marketing management: Role of marketing in small industry and business. Importance of consumer's point of view, consumer behavior, buying habits, marketing, packing, pricing policies and practices, product mix-segmentation of marketing, sales control, appraisal of sales performance, management of receivables, Advertising and sales promotion, Introduction to import/export procedures; Problem solving and innovation; Industrial and business laws: Laws governing business operation, laws governing taxation, laws governing personnel.

Essential Reading:

**ME 4212 WELDING TECHNOLOGY**

3 credits [3-0-0]

Introduction, types of welding, conventional and non conventional welding, fusion welding processes, heat flow in welding, chemical reactions in welding, fluid flow and metal evaporation in welding, residual stresses, distortion and fatigue, basic solidification concepts, weld metal solidification; grain structure, microstructure within grains, post solidification phase transformation, weld metal chemical in homogeneities, weld metal solidification cracking, the partially melted zone: formation of the partially melted zone, difficulties associated with the partially melted zone, the heat affected

Nomenclature of welded joint, types of welded joint, design consideration of weldment, failure analysis of the welded joint, testing of weldment, process control parameters of welding, properties of desired weldment: bead geometry, HAZ, mechanical-metallurgical characteristics of the weld, weld chemistry, parametric optimization of welding, different types of optimization techniques, advantages and limitations, case study.

Essential Reading:

Supplementary Reading:

**ME 5306 COMPUTATIONAL FLUID DYNAMICS 3 credits [3-0-0]**


Essential Reading:

Supplementary Reading:

**ME 3304 POWER PLANT ENGINEERING 3 credits [3-0-0]**

Vapor Power Cycles: Rankine cycle, Comparison of Rankine and Carnot vapor cycles, Regenerative cycles, Ideal working fluid for vapor power cycles, Binary vapor cycle, Thermodynamics of couples cycles, Process heat and by-product power. ; Steam Generators: Classification of boilers, Description of Cochran, Lanchashire and Babcock-Wilcox boilers, Boiler mounting and accessories, High pressure boilers, Lamont, Benson and Velox boilers. ; Nozzle: Introduction, Types of nozzles, Flow of steam through nozzles, Momentum equation, Entropy change with friction, Effect of friction, Calculation of nozzle area, Mass flow, Critical pressure, Stagnation enthalpy and pressure, Effect of friction on critical pressure ratio, Super-saturated flow in nozzles, Effect of variation of back pressure. ; Steam Turbines: (a) Principles of operation of steam turbine, Types of steam turbine, Compounding of steam turbine. (b) Impulse Turbine: Velocity diagram, Effect of blade friction, Forces on Blades, Work done, Diagram efficiency, Stage efficiency, Gross stage efficiency, Choice of blade angles, Blade heights etc. (c) Impulse Reaction Turbine: Velocity diagram, Degree of reaction, Parson's turbine, Blade sections, Internal losses in steam turbine, State point

Essential Reading:

**ME 3104 AUTOMOBILE ENGINEERING** 3 credits [3-0-0]

Types of automobiles, vehicle construction and layouts, chassis, frame and body, Vehicle aerodynamics (various resistances and moments involved), IC engines – components-functions and materials, variable valve timing (VVT), Electronically controlled gasoline injection system for SI engines, Electronically controlled diesel injection system (Unit injector system, Rotary distributor type and common rail direct injection system), Electronic ignition system (Transistorized coil ignition system, capacitive discharge ignition system), Turbo chargers (WGT, VGT), Engine emission control by three way catalytic converter system, Emission norms (Euro and BS). Clutch-types and construction, gear boxes- manual and automatic, gear shift mechanisms, Over drive, transfer box, fluid flywheel, torque converter, propeller shaft, slip joints, universal joints,Differential and rear axle, Hotchkiss Drive and Torque Tube Drive. Steering geometry and types of steering gear box- Power Steering, Types of Front Axle, Types of Suspension Systems, Pneumatic and Hydraulic Braking Systems, Antilock Braking System (ABS), electronic brake force distribution (EBD) and Traction Control. Use of Natural Gas, Liquefied Petroleum Gas, Bio-diesel, Bio-ethanol, Gasohol and Hydrogen in Automobiles- Engine modifications required –Performance, Combustion and Emission Characteristics of SI and CI engines with these alternate fuels - Electric and Hybrid Vehicles, Fuel Cell Note: Practical Training in dismantling and assembling of Engine parts and Transmission Systems should be given to the students.

Essential Readings:

**ME 4302 ENERGY CONSERVATION & WASTE HEAT RECOVERY** 3 credits [3-0-0]

Pattern of energy use, potential for energy conservation, optimum use of energy resources, total energy approach. Coupled cycles, combined plants and cogeneration systems ; Need for energy storage, thermal electrical, magnetic and chemical energy storage systems ; Utilization of industrial waste heat; gas-to-liquid and liquid-to-liquid heat recovery systems; Recuperation and regenerators heat pipes; waster heat boilers; fluidized bed heat recovery; shell and tube heat exchangers ; Prime mover exhausts;
incineration plants; heat pump systems; thermoelectric devices; Utilization of low grade reject heat from power plants; Thermal insulation; energy economics.

Essential Reading:

<table>
<thead>
<tr>
<th>ME 4301</th>
<th>NUCLEAR POWER GENERATION AND SAFETY</th>
<th>3 credits [3-0-0]</th>
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Essential Reading:

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<tr>
<th>ME 4305</th>
<th>CRYOGENIC ENGINEERING</th>
<th>3 credits [3-0-0]</th>
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Essential Reading:

<table>
<thead>
<tr>
<th>ME 4152</th>
<th>DESIGN ENGINEERING LABORATORY</th>
<th>1 credits [0-0-2]</th>
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<tbody>
<tr>
<td></td>
<td>Critical speed of shafts; Measurement of damping; Study of cam and follower kinematics; Experiment on vibration measurement set-up; Experiment on gyroscope; Study of dynamic balancing machine; Balancing of a rotating shaft; Experiment on epicyclic gear trains; Calibration of photoelastic model; Isochromatic fringe pattern for a specimen under bending; Calibration of strain gauge; Stress measurement using strain rosette; Experiment on journal bearing test rig; Experiment on abrasion tester; Erosion tester; Ferrograph analysis.</td>
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<thead>
<tr>
<th>ME 4352</th>
<th>THERMAL ENGINEERING DESIGN PROJECT</th>
<th>1 credits [0-0-2]</th>
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<tr>
<td></td>
<td>Mathematical modeling and curve fitting of linear algebraic systems; Numerical model for a Thermal system and System simulation; Calculation of interest and worth of money as a function of time; Lagrange multipliers and Optimization of constrained and...</td>
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unconstrained problems ; Search methods: Single-variable problem and Multivariable constrained optimization ; Design of thermal systems: Geometric, linear, and dynamic programming

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<tr>
<td>ME 4154</td>
<td>MECHATRONICS AND ROBOTICS LAB.</td>
<td>1</td>
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<td>Study of Mechatronics system, Study of Mechatronics sensors, Study of Mechtronics actuators, Study of Robot controllers, Study of Robot behavior.</td>
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<tr>
<td>ME 4254</td>
<td>INNOVATIVE PROJECT</td>
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<td>Product definition, Cause-effect diagram, Idea generation, Evaluation, Morphology analysis, SWOT Analysis, Objective tree, Functional tree, Specifications, Fabrication</td>
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<tr>
<td>ME 4151</td>
<td>MECHANICAL SYSTEM DESIGN PROJECT</td>
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<td>Introduction and salient features of EOT crane design ; Design of trolley structure ; Design of main girder ; Design of side truss ; Design horizontal truss ; Design of members ; Design of gantry girder and column ; Design of mechanical components, rope, pulley, drum ; Design of crane hooks, brakes, drives etc. Problems for practice on theories of failure ; Problems for practice on fatigue and failure ; Design of Journal bearings ; Design of ball bearings, roller bearings ; Design of valves of IC engines</td>
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<tr>
<td>ME 4252</td>
<td>INDUSTRIAL ENGINEERING PROJECT</td>
<td>1</td>
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<td>Generation and Testing of Random numbers: Solution of Queuing problem ; Design of Network system and find its optimal solution ; Formulation and solution of practical industrial problems using LP ; Solution of Transportation and Assignment problem ; Conceptual Design of a product focused system for high volume rate ; Design of Functional Layout using numerical technique ; Conceptual Design of a job shop for optimal man&amp; machine use ; Optimal cell formation for batch production ; Brain storming session to reach an optimal decision point ; Design and determination of Optimal Schedule for Maintenance for a medium plant ; Application of advanced forecasting techniques for sales ; Acquaintance with advanced Flow shop and Job Shop scheduling techniques</td>
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<tr>
<td>ME 4203</td>
<td>RAPID TOOLING</td>
<td>3</td>
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STL files, Solid View, Magics, Imics, Magic communicator, Internet based software, Rapid Manufacturing – Introduction, Factors influencing accuracy, Data preparation errors, Part building errors, Errors in finishing, Influence of build orientation

Essential Reading:

ME 4202 PRODUCTION AND OPERATION MANAGEMENT 3 credits [0-0-3]

Production Management: Integrated Production Management, System Productivity, Capital Productivity, Labour Productivity, Personnel Productivity, Training
Supply Chain Management : Introduction, Domain Applications, SCM– The Breakthrough Article, Supply Chain Management, Views on Supply Chain, Bullwhip Effect in SCM, Collaborative Supply Chain, Inventory Management in Supply Chain, Financial Supply Chain – A New Revolution within the SCM Fold
Operations Scheduling: Introduction, Purpose of Operations Scheduling, Factors Considered while Scheduling, Scheduling Activity under PPC, Scheduling Strategies, Scheduling Guidelines, Approaches to Scheduling, Scheduling Methodology
[Quantitative], Scheduling in Services, Value Engineering: Introduction, Value Engineering/Value Analysis, Relevance of VE in Modern Manufacturing, Process of Value Analysis, VE – Approaches and Aim, Providing Value to the Customers, Benefits, Just-In-Time : Introduction, Characteristics of JIT, Key Processes to Eliminate Waste, Implementation of JIT, Pre-requisites for implementation, JIT Inventory and Supply Chains

Essential Reading:

**ME 3171 MECHANICS OF MATERIALS**

3 credits [0-0-3]

- Load, Stress, Principle of St. Venant, Principle of Superposition, Strain, Hooke’s law, Modulus of Elasticity, Stress-Strain Diagrams, Working Stress, Factor of safety, Strain energy in tension and compression, Resilience, Impact loads, Analysis of Axially Loaded Members: Composite bars in tension and compression - temperature stresses in composite rods, Statically indeterminate problems. Shear stress, Complimentary shear stress, Shear strain, Modulus of rigidity, Poisson’s ratio, Bulk Modulus, Relationship between elastic constants.
- Members in Biaxial State of Stress and strain: Stresses in thin cylinders, thin spherical shells under internal pressure. Analysis of Biaxial Stress. Plane stress, Principal stress, Principal plane, Mohr’s Circle for Biaxial Stress. Principal strains and principal axes of strain measurements, Calculation of principal stresses from principal strains.
- Shear Force and Bending Moment for Simple Beams: Shear force and bending moment. Types of load and Types of support. Support reactions, Relationship between bending moment and shear force, Point of inflection. Shear Force and Bending Moment diagrams.
- Simple Bending of Beams: Theory of simple bending of initially straight beams, Bending stresses, Shear stresses in bending, Distribution of normal and shear stress, beams of two materials, Composite beams.
- Deflection of Beams: Differential equation of the elastic line, Slope and deflection of beams by integration method and area - moment method.
- Torsion in solid and hollow circular shafts, Twisting moment, Strain energy in shear and torsion, strength of solid and hollow circular shafts. Stresses due to combined bending and torsion, Strength of shafts in combined bending and twisting.
- Close - Coiled helical springs.

**Essential Reading**
2. Strength of Materials by R. Subramaniam, Oxford University Press

**Supplementary Reading**
3. Strength of Materials by James M. Gere and Barry J. Goodno, Cengage Learning
ME 4109  NUMERICAL MODELING OF ENGINEERING SYSTEMS  3 credits [0-0-3]

Finite difference method: Basics, forward and central differences, solution of partial differential equations, Applications to 1-D and 2-D steady-state and transient problems in structural, thermal and fluid mechanics with boundary conditions.

Finite element method: General procedure, Energy methods, Weighted residual methods, Shape functions and stiffness formulation of 1-D spar and beam elements, 2-D triangular and rectangular plate elements, Axisymmetric elements, 3-D tetrahedral and brick elements, Applications to heat transfer, fluid mechanics and structural dynamics.


Introduction to finite volume methods and coupled thermos-mechanical analysis examples via Ansys Fluent and ABACUS modeling.

Essential reading:

Supplementary Reading:

ME 4371  FLUID MECHANICS & FLUID MACHINERY  3 credits [3-0-0]


Boundary layer growth over a flat plate, Boundary layer thickness, Displacement thickness, Momentum thickness and energy thickness, Laminar and turbulent boundary layer,

Turbines: Classification, Study of Pelton, Francis and Kaplan Turbines, Blade Angle, Velocity Triangle, Efficiencies. Specific speed unit quantities, Performances of turbines, Principle of similarity applied to turbines. Centrifugal Pumps: Principle and Classification, Efficiency, Specific speed, Characteristic curves, Multi stage pumps, Pumps in series and parallel, Principle of similarity applied to pumps, cavitation in pumps, NPSH. Reciprocating Pump: Principle of working, Slip, Work done, Effect of

Essential reading:
2. B. S. Massey, *Mechanics of Fluids* by ELBS.
Supplementary reading:

**ME 3571 MECHANICAL ENGINEERING LAB.-I** 1 credits [0-0-2]

Calibration of slip gauge using interference of light by Interference Method; Internal taper and bore measurement using two precision spheres; External taper measurement by sine center Study of Two/Four stroke petrol/diesel engine; Determination of volumetric efficiency of reciprocating air-compressor; Valve timing diagram of four-stroke petrol/diesel engines; Load test on petrol engine. Measurement of thermal conductivity of solid by gaupered hot plate method; To determine the efficiency of a pin-fin in natural and forced convection

**ME 3572 MECHANICAL ENGINEERING LAB.-II.** 1 credits [0-0-2]

Experiment on machining in machining center (CNC); Condition monitoring in machining processes using acoustic emission; Experiments on Ultra Sonic Machining; Experiments on Electro Discharge Machining; Experiments and demonstration of Laser Machining; Experiments and demonstration of Electro Chemical Machining process; Experiments and demonstration of Abrasive Jet Machining; Programming on various CNC machine tools and use of CIM; Load test on diesel engine; Morse test on multi-cylinder petrol/diesel engine; Heat Balance study of petrol/diesel engine; Study of differential and transmission system of automobile; Study of 4-speed/5-speed gear box of automobile. Performance study of vapour compression refrigeration test rig; Determination of COP and tonnage capacity of ammonia ice plant

**ME 4107 INDUSTRIAL MACHINE DESIGN** 3 credits [3-0-0]

Design of IC Engine Components: Design of cylinder and Cylinder head, Design of piston, Design of connecting rod, Design of crankshaft and Design of valve-gear mechanism

Design of Cranes: Basic objectives of material handling system, Types of load, Classification and application of various Material handling equipment, Basic principles in selection of material handling system, Classification of cranes, Stress analysis and selection of Hooke (IS 15560, 2005), Pulley System (hoisting tackle analysis), Steel Wire ropes: Classification and coding, stress analysis and selection, Design of Sheave and drums.

Component & assembly design, use of CAD procedure for designing, application of optimization techniques, modeling and evaluation of components & assembly, specific examples to be taken such as centrifugal pump, wind turbines, machine tools etc. calculation of stresses and strengthening of blades.

Essential reading:
ME 5208 MODERN MANUFACTURING PROCESSES 3 Credits [3-0-0]

Modern Machining Processes: Electro Discharge Machining (EDM), Processes mechanism of material removal, parameters effects EDM & application, Electrical Discharge Grinding(EDG), Traveling Wire EDM, Electro-chemical Machining (ECM), Processes, Mechanism of material removal, Tool design, Parameters affecting ECM, Applications, Electro-chemical Honing(ECH), Electrochemical Debarring (ECD), Electrochemical Grinding(ECG), Electrochemical Discharge Grinding, Chemical Machining, Ultrasonic Machining, Cutting Tool System Design, Mechanism of cutting, Parameters affects USM applications, Abrasive Jet Machining, Variables of AJM, Nozzle Design, Laser Beam Machining, Thermal and Non-thermal analysis, and applications, Electron – Beam Machining and its mechanism, Applications, Plasma arc machining, Equipments, Arc transfer mechanism, Metallurgical efforts, Safety precautions and applications, Plasma are surfacing and plasma Arc Spraying, Iron Beam machining and water Jet Machining. ; Modern forming processes: Measurement of stress and strain under high strain rate, principles of drop forging operation cam plastometer and mushrooming of billets, formability criteria, explosive forming, electro hydraulic forming, magnetic pulse forming, pneumatic mechanical high velocity forming, comparison with conventional process, introduction to kinetic forming, explosive welding.

Essential Readings:
1. *HMT - Production Technology* - TMH, 1980. (Chapter 14)
2. *ASME -High velocity forming of metals*, PHI. (Chapters 2, 4, 5, 6, 7 and 8)

Supplementary Reading:
2. Fishlock and Hards, *New ways of working with metals* - Gerge Newnes.

ME 5205 QUALITY ENGINEERING AND RELIABILITY 3 Credits [3-0-0]


Essential Reading:
1. Freund and Miller, *Statistics for engineering and scientists* by PHI
2. *Quality Engineering using Robust design* by M/s phadke, Prentice Hall.
ME 5303 ADVANCED IC ENGINE TECHNOLOGY 3 Credits [3-0-0]


Essential Reading:

Supplementary Reading:
3. K.K. Ramalingam, Internal Combustion Engine Fundamentals, Scitech Publications,
6. V. Ganesan, Computer simulation of compression ignition engine. Orient Long man

ME 5104 VIBRATION ANALYSIS & DIAGNOSTICS 3 Credits [3-0-0]


Essential Reading:
Supplementary Reading:

**ME 3272 ADVANCED MANUFACTURING PROCESSES** 3 credits [3-0-0]

Modern Machining Processes: Electro Discharge Machining (EDM), Processes mechanism of material removal, parameters effects EDM & application, Electrical Discharge Grinding(EDG), Traveling Wire, EDM, Electro-chemical Machining (ECM), Processes, Mechanism of material removal, Parameters affecting ECM, Applications, Chemical Machining, Ultrasonic Machining, Abrasive Jet Machining, Laser Beam Machining, Electron Beam Machining, Plasma arc machining, Fundamental of Manufacturing and Automation: Production operation and automation strategies, Manufacturing industries, Types of production function in manufacturing, Production concept and mathematical models, Automation strategies. Cost-benefit analysis.


**Essential Readings:**

**ME 2271 BASIC MANUFACTURING PROCESSES** 3 credits [3-0-0]

Introduction about manufacturing process; classification of manufacturing process;

Foundry : Introduction to patterns and foundry, Sand binders and different additives, Sand testing; melting furnaces for ferrous and non-ferrous metals such as cupola, Induction furnace, Arc furnace & Resistance Furnace; sand casting, continuous casting, investment casting, centrifugal casting, die casting, Casting defects.

Welding: classification of welding, gas welding, arc welding, TIG (GTAW) and MIG (GMAW) welding, resistance welding and thermit welding; Advanced Welding methods: plasma Arc, Laser Beam, Electron Beam, Ultrasonic, Explosive and friction welding; Brazing and soldering, welding defects.

Plastic deformation of metals: Hot and cold working of metals; Rolling: types of rolling mills, Rolling defects ; Forging: Smith Forging, Drop and Press forging, M/C forging, Forging defects; Extrusions: Direct, Indirect, Impact and Hydrostatic extrusion, Extrusion of tubes; Wire drawing methods and variables in wire-drawing; Sheet metal working: Bending, Forming and deep drawing.

Powder Metallurgy Method: Steps and Applications
Different types of machine tools for metal cutting: Lathe, Milling machine, Drilling machine, Grinding machine; Tool holding and job holding methods in different M/C tools, Indexing mechanism and thread cutting mechanism.

Essential Reading:

2. P. N. Rao, Manufacturing Technology – Vol-I and II, TMH
3. P.C.Pandey and H.S.Shen, Modern Machining process.

ME 4172  DYNAMICS AND DESIGN OF MACHINES  3 credits [3-0-0]

Force analysis: Static forces in 4-bar mechanism, slider-crank mechanism, quick-return mechanism. Dynamics of reciprocating engine mechanism (analytical method).
Turning moment diagram and flywheel: Fluctuation of crank shaft speed, flywheel in IC engine, punching press, analytical expression for turning moment.
Governors and Gyroscopes: Types of governors, performance parameters, Governor effort and power, controlling force, friction and insensitiveness, centrifugal effect of revolving arms, gyroscopic forces and couple.
Vibration Analysis: Natural frequency, equivalent system, energy method, Free vibration response, damping, single degree of freedom system with viscous damping, bending critical speeds of simple and multi-mass shafts, torsional system.
Introduction to machine design, methodology, strength, rigidity, fracture, wear, and material considerations in design, use of standards, Selection of materials and processes. Standard numbering system including BIS designations of materials. Concept of factor of safety. Application of theories of failure to design.
Design of shafts, keys and couplings, belt drive, clutches and spur gears.

Essential Reading:

4. S.S. Rattan, Theory of Machines, MGH
5. R.K.Bansal, Theory of Machines, Laxmi Publisher

Supplementary Reading:

4. Rao & Dukkipati, Mechanism and Machine Theory, New Age
5. Ghosh & Mallick, Theory of Mechanism & Machines, East West Press

MM 2XXX  BASIC PHYSICAL METALLURGY  2 credits [2-0-0]

Crystal systems and lattices: Crystallography, crystals and types, miller indices for directions and planes, voids in crystals, packing density in crystals, Crystal imperfections. Characteristics of dislocations, generation of dislocations; Bonds in solids and characteristics of Metallic bonding;
Deformation mechanisms and Strengthening mechanisms in structural materials;
Principles of solidification: Structural evolution during solidification of metals and alloys. Phase diagrams: Principles, various types of phase diagrams. Iron carbon equilibrium phase diagrams, TTT diagrams; Pearlitic, martensitic, and bainitic transformations; Various heat treatment processes of steels; Hot working and cold working of metals; Recrystallization and grain growth phenomenon; General classifications, properties and applications of alloy steels, tool steels, stainless steels, cast irons, copper base alloys, Aluminum base alloys, Nickel base alloys, composites, ceramics and polymers.
Essential Readings:
1. G.E. Dieter, Mechanical Metallurgy, McGraw Hill,

Supplementary Reading:

EE 2XXX ELECTRICAL MACHINES 3 credits [3-0-0]

Essential reading:

Supplementary reading:

DEPARTMENT OF METALURGICAL & MATERIALS ENGINEERING

MM 2301 Metallurgical Thermodynamics and Kinetics 3-1-0 4

Basic concepts of systems; State and Path functions; Internal energy and Thermodynamics Processes; First law of thermodynamics and its application for various metallurgical processes; Heat capacity; Enthalpy changes; Second law of thermodynamics and entropy; Entropy changes for various processes; Free energy and its significance; Free energy change as a function of temperature; Gibbs – Helmholtz equation; Concepts of standard state, fugacity, activity and equilibrium constant; Van’t Hoff equation; Criteria for thermodynamic equilibrium; Maxwell’s equations; Third law of thermodynamics; Ellingham diagram ($\Delta G^0 – T$ diagram) and its significance in Metallurgical Engineering; Thermodynamics of solutions; Gibbs – Duhem equation; Raoult’s law; Ideal, non-ideal and regular solutions and their thermodynamic properties; Henry's law and alternative standard states, relation between Free energy change and electromotive potential; Excess quantities; Activities in multi-component systems. Basic concepts of reaction rates; Arrhenius equation in reaction kinetics; Mechanism of reaction and rate controlling steps; Activated complex and its thermodynamic & kinetics aspects; Kinetics of heterogeneous reactions; Fick’s laws of diffusion and their applications; Mass transfer at solid-fluid interface; Mass transfer coefficient and its application to dimensional analysis; Concept of concentration boundary layer; Kinetic steps involved in the reduction of iron ore and roasting of sulphides.
Essential Reading:

Supplementary Reading:

MM 2302 Transport Phenomena 3-0-0 3


Essential Reading:

Supplementary Reading:

MM 2303 Iron making 3-0-0 3


Essential Reading:

Supplementary Reading:

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Essential Reading:

Supplementary Readings:

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Thermodynamics and Kinetics of solid state Phase transformation, Atomic models of Diffusion, Allotropy of Iron and Fe-C Phase diagram, Functions of alloying elements, Importance of Austenite Grain size; Formation of Austenite, TTT and CCT Diagrams, Homogeneous and Heterogeneous nucleations, Strain energy effects; Overall Transformation Kinetics, Empirical equations, Transformation kinetics for Interface-controlled and Diffusion-controlled growth; Pearlitic, Bainitic and Martensitic Transformations (Mechanisms, Kinetics and Morphologies). Pearlitic transformation, Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship; Bainitic transformation:

**Essential Reading:**
2. V. Raghavan, *Solid State Phase Transformations*, PHI.

**Supplementary Reading:**

<table>
<thead>
<tr>
<th>MM 3201</th>
<th>Deformation Behaviour of Materials</th>
<th>3-0-0</th>
<th>3</th>
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**Essential Reading:**

**Supplementary Reading:**

<table>
<thead>
<tr>
<th>MM 3304</th>
<th>Steelmaking</th>
<th>3-0-0</th>
<th>3</th>
</tr>
</thead>
</table>

Introduction: Principles of steel making reactions, Viz. Decarburisation, dephosphorisation, desulphurisation, silicon and managanese reaction. Slag Theories: Molecular and Ionic theories; Interpretation of the above reactions in terms of ionic theory of slag. LD Process:

Essential Reading:

Supplementary Reading:

| MM 3103 | Heat Treatment of Metallic Materials | 3-0-0 | 3 |


Essential Reading:

Supplementary Reading:


| MM 3202 | Mechanical Properties of Materials | 3-0-0 | 3 |


**Essential Reading:**

**Supplementary Reading:**

| MM 3203 | Manufacturing Processes | 3-0-0 | 3 |


| MM 4204 | Mechanical Working of Metallic Materials | 3-0-0 | 3 |

Fundamentals of Metal Working: Classification of forming processes; Temperature in Metal—working, Hot working, Cold working and Warm working of metals, Heating of metals and alloys for hot working, Friction in Metal working, Lubrication, concept of yield criteria. Rolling of Metals: Classification of Rolled products, Types of rolling mills, Terminology used in rolling; Forces and Geometrical relationships in rolling, Rolling variables, Theories of rolling, Rolling Torque and HP calculations. Roll-pass Design: Fundamentals of Roll-pass-design; Mill type, Layout and rolling practice adopted for some common products such as Slabs, Blooms, Billets, Plates, Sheets etc. Rolling defects and their control. Forging of Metals: Forging principles, types of forging and equipments needed; calculation of forging load under sticking and slipping friction conditions. Forging defects and their control. Manufacture of rail wheels and tyres.
Extrusion: Types, Principles and Equipments. Variables in extrusion, deformations in extrusion, calculation of extrusion pressure under plane strain conditions; extrusion defects; production of tubes and seamless pipes. Wire Drawing: Drawing of Rods, Wires and Tubes, calculation of drawing load; drawing defects. Sheet Metal Forming: Forming methods such as bending, stretch forming, shearing and blanking, deep drawing, and redrawing. Defects in formed products. Special forming methods such as explosive forming (elementary ideas excluding mathematical treatment).

Essential Reading:
2. *Roll pass Design*, the united steel companies Ltd., U.K.-1960

Supplementary Reading:

| MM 4501 | Corrosion and Environmental Degradation of Materials | 3-0-0 | 3 |

Definition of corrosion, Cost of corrosion, Classification of corrosion, Electrochemical aspect of corrosion, Eight forms of corrosion (Uniform attack, Galvanic corrosion, Crevice corrosion, Pitting, Intergranular corrosion, Selective leaching, Erosion corrosion, Stress corrosion), Hydrogen damage, Basic thermodynamics of corrosion (Concept of free energy, Cell potential, EMF and Galvanic series, Relationship between free energy and cell potential, Nernst equation, Application of thermodynamics to corrosion, Pourbaix diagram), Kinetics of corrosion (Exchange current density, Activation polarization, Concentration polarization, Combined polarization, Mixed potential theory, Mixed electrodes, Passivity), Oxidation and hot corrosion of materials at high temperature, Kinetics of oxidation, Pilling-Bed worth ratio. Corrosion testing (Corrosion rate measurement by immersion testing, Expression for corrosion rate, Measurement of open circuit potential, Potentiodynamic polarization scan (Taffel's plot), Linear polarization, Electrochemical Impedance Spectroscopy), Corrosion prevention (Selection of proper materials, Design rules and its modifications, Alloying additions, Environmental conditioning, Cathodic and anodic protection, Organic and inorganic coating, Surface engineering, Inhibitors and passivators).

Essential Reading:

Supplementary Reading:

| MM 4401 | Modelling of Materials Processes | 3-0-0 | 3 |

Molecular simulations, numerical methods, image processing, modelling of simple systems and animation. MATLAB and Simulink software for all modelling and simulations. This course also includes topics viz., matrices, solution to ODEs, making simple 2-D and 3-D geometrical figures
using parametric equations, colour maps, meshgrids, 2-D and 3-D plots and contours. Several numerical techniques like Newton-Raphson technique, Runge-Kutta method, Simpson's 1/3 rule are taught in detail in this course. Topics and problems based on material properties, crystal structures, structure-property correlation in materials are considered for modelling in this course. Students will be taught how to develop and run sample programs. This course also gives an introduction to image processing, animation, making movies and sound processing.

Recommended Textbooks:


Overview of processing, microstructure and property relations of engineering materials; Different material choices in design; Material designing – Types and tools used; Important design related properties of engineering materials; Material Indices and its determination relevant to variety of metallurgical applications; Material selection bubble charts – creation and interpretation; Materials selection by optimising the performance; Shape Factors in material selection; Multiple material constraints and identifying the active constraints in selecting materials; Conflicting Objectives/Material Substitution using exchange constants and penalty functions. Different case studies, involving traditional and software approaches, for materials design and selection for a wide range of metallurgical applications.

Essential Reading:


Supplementary Reading:


Introduction of fossil fuels and their world-wide reserves; Primary and secondary fuels, Coking and non-coking coals. Beneficiation of coal. Characterization of coal properties (caking and swelling indices, calorific value, proximate and ultimate analyses, etc.); Coal carbonization and effects of different parameters; Properties of coke, char and graphite. Selection of coal for sponge iron making and thermal power plants; Fuel combustion and the effects of different factors; Combustion calculations. Alternative sources of energy (viz. ferro-coke, formed coke, charcoal, solar, wind, tidal, etc.) and their suitability for metallurgical and power industries;
Renewable and non-renewable sources of energy; Activated carbon and its uses; Modern trends in the utilization and conservation of fossil fuels. Properties and uses of gaseous fuels like coke oven gas, blast furnace gas, basic oxygen furnace gas, producer gas, etc.; Petroleum coke and its utilization in metallurgy. Solid energy wastes and their possible industrial applications; World-wide approach in the utilization of energy wastes; Energy crises and its possible solution.

Refractories: Classification of refractories. Properties and applications of Fireclay, Silica, Chromite, Carbon/Graphite, Magnesite, Dolomite, Zirconia, Silicon Carbide, Sillimanite, Kyanite refractories.

Selection of Refractories: Blast Furnace, LD Converter, Electric Arc Furnace.

Essential Reading:

Supplementary Reading:

<table>
<thead>
<tr>
<th>MM 2306</th>
<th>Non Ferrous Metal Extraction-Principle and Practice</th>
<th>3-0-0</th>
<th>3</th>
</tr>
</thead>
</table>

Principles of Extraction of Metals – I (Mineral Processing): Ore and ore body, parameters defining economy of ore processing, Liberation, communication, crushing, grinding, sizing, classification, Principles of minerals beneficiation such as heavy media separation, jigging, tabling, magnetic separation, Flotation, Solid – Liquid separation.


1. Pyrometallurgical extraction of copper: flowsheet, flotation, roasting, matte smelting, converting, refining.
2. Pyrometallurgical extraction of nickel: flowsheet, roasting, matte smelting, (3) Pyrometallurgical extraction of ladle: flowsheet, flotation, roasting, sintering, smelting, refining.


2. Pressure – Leaching – EW.
3. Hydrometallurgy of copper; flowsheet, heap leaching/bioleach/roast – leach, solvent extraction, electrowinning.

Essential Reading:

Supplementary Reading:

Essential Reading:

Supplementary Reading:

Supplementary Reading:

**MM 2105**  |  **Physics of Materials**  |  3-0-0  |  3


**MM 2502**  |  **Powder Technology**  |  3-0-0  |  3

Generation of X-ray, continuous and characteristics, spectrum of X-rays, filters, coherent scattering and diffraction under non-ideal conditions, intensity of diffracted beams, X-ray Diffraction, Bragg’s Law, Laue, Rotating Crystal and Powder Methods, Structure Determination, precise lattice parameter determination, solvus line, chemical analysis. Preferred orientation and texture.


Thermal characterization techniques: Theory, Thermo Gravimetric Analysis (TGA), Instrumentation, Applications; Differential Thermal analysis (DTA), Apparatus, Methodology, Applications; Differential Scanning Calorimetry (DSC), Applications; Dilatometer. Chemical characterization techniques: Principle underlying techniques, Infrared spectroscopy (IR), Raman spectroscopy.

Essential Reading:

Supplementary Reading:
fullerene and nanotubes, Core-shell structures, Organic-inorganic hybrids, Intercalation compounds, Mesoporous materials, Nanocomposites.

**Essential Reading:**

**Supplementary Reading:**

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**MM 3307** Advances in Steelmaking  
3-0-0  
3

Objectives and techniques adopted in Secondary Steelmaking like vacuum degassing processes: ladle degassing processes (VOD, VAD), steam degassing processes, circulation degassing processes (RH, DH). Inert gas purging, ladle furnace, etc. Role of slag and powders in inclusion control; Desulphurization; Dephosphorisation; Modifications of inclusion morphologies, production of ultra low carbon, ultra low sulphur, ultra low phosphorus and inclusion free steels; Powder injection system. Production of stainless steels through VOD, AOD and CLU processes. Production of ultraclean steel through post solidification treatments (VAR, ESR processes); Refractories used in secondary steelmaking furnaces, their properties and selection criteria.

**Essential Reading:**

**Supplementary Reading:**

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**MM 3505** Advances in Materials  
3-0-0  
3


**Essential Reading:**
MM 3402 Molecular Modelling of Materials 3-0-0 3

Computational materials science-introduction, basic procedures, first-principles methods (ab-initio methods), Monte-Carlo methods, Molecular dynamics, finite element analysis, atomistic model in molecular dynamics, classical mechanics, Binding energy, Potentials, pair potentials-EAM, Tersoff, MEAM, L-J, Solution for Newtons equation of motion- N-atom system, Verlet algorithm, Velocity-verlet algorithm, Initialization, Integration equilibration-energy minimization, newton raphson, steepest gradient, conjugate gradient method boundary conditions-periodic, non-periodic, fixed, ensembles-NVT, NPT, NVE, structural characterization-radial distribution function, data production-run analysis, equilibrium lattice constant, mean-square displacement, cohesive energy, introduction to LAMMPS (Large Scale Atomic Molecular Massively Parallel Simulator)- creation of fcc, bcc lattice, nano-indentation, shear, tensile, polycrystalline material model and simulations, visualization tools-VMD, OVITO.

Essential Reading:


Supplementary Reading:


MM 3506 VACUUM TECHNOLOGY IN MATERIALS ENGINEERING 3-0-0 3

Introduction – Basics of vacuum system and vacuum technology- Classification of vacuum and their applications - Vacuum metallurgy - Melting, Refining and Casting for steels and other metals and alloys – Vacuum sintering of powder compacts - advanced sintering methods - HIP (hot isostatic pressing), SPS (Spark Plasma Sintering), PPS (Pulse Plasma Sintering) and Hot Pressing, Heat treatment in vacuum - Vacuum hardening and tempering - Vacuum Case hardening-Carburizing /Nitriding - Joining of materials in vacuum – Vacuum brazing of similar or dissimilar materials - SS-Al, SS-Cu, SS-Kovar, SS-Al2O3 Welding in Vacuum- Diffusion bonding – Ag-Cu, Ag-Cu-Ti Different grade of brazing filler metals and alloys – their applications – Vacuum technology for advanced characterization equipments (SEM/TEM/AFM) and some practical case studies.

Essential Reading:

2. London.
3. Dayton BB, 1998, in Foundation of Vacuum Science and Technology, J Lafferty,

Essential Reading:

Supplementary Reading:

Introduction: Principle, Theory and Classification of welding and other joining processes. Manual metal arc (MMA): Equipment requirement, electrodes for welding of structural steels, coating constituents and their functions, types of coatings, current and voltage selection for electrodes, Arc welding power sources; Conventional welding transformers, rectifiers and current and voltage. The influence of these power sources on welding. Metal transfer. Submerged arc welding (SAW): Process details, consumables such as fluxes and wires for welding mild steel, Variations in submerged arc welding process. Gas metal arc welding (GMAW) or MIG/ MAG welding: Process details, shielding gases, electrode wires, their sizes, and welding current ranges. TIG welding: Process details, power sources requirements,

**Essential Reading:**
2. R L Little, *Welding and Welding Technology*, TMH.

**Further Reading:**

### MM 4205 | Fracture, Fatigue and Wear of Metals


**Essential Reading:**

**Supplementary Reading:**

### MM 4507 | High Temperature Materials

Introduction-Problem with materials at high temperature; Background-Time dependent deformation; Difference between ambient and elevated temperature plastic deformation

Theories of Creep: Definition of creep; Different methods of creep testing; Creep curve; Effect of stress and temperature on creep curve; Effect of microstructure on creep; Mechanism of
creep deformation - Lattice mechanism - Dislocation glide, dislocation climb, Boundary mechanism-Nabarro-Herring, Coble, Grain boundary sliding; Determination of stress exponent and activation energy for steady state creep; Creep behaviour of nanocrystalline materials; Deformation mechanism maps;
Stress-rupture tests; Difference between creep and stress-rupture test; Presentation of engineering creep data-Monkman-Grant relationship, Larson-Millar parameter;
Superplasticity;
Strengthening mechanisms of high temperature materials, Basis for development of creep resistant materials; Materials for elevated temperature application - High temperature steels and their applications, Ni-base superalloys and their applications; Creep fracture micro-mechanisms;

Reference Books:


**MM 4508 Surface Engineering**

| Philosophy of surface engineering, general applications and requirements. Basic principles of electrochemistry and aqueous corrosion processes. Friction and Wear: Abrasive, erosive and sliding wear. The interaction between wear and corrosion.
| Surface Engineering techniques: conventional and modern. Heat treatment, laser processing, plasma processing, energy beam processing, PVD, CVD, deposition etc.
| Analytical Techniques for surface characterization: X-ray diffraction, TEM, SEM and EDX, WDX analysis. Surface analysis by AES, XPS and SIMS, overview of other techniques. Data interpretation and approaches to materials analysis.

**Essential reading:**

**Supplementary Reading:**

**MM 4509 Nanostructured Materials**

| Philosophy of surface engineering, general applications and requirements. Basic principles of electrochemistry and aqueous corrosion processes. Friction and Wear: Abrasive, erosive and sliding wear. The interaction between wear and corrosion.
| Surface Engineering techniques: conventional and modern. Heat treatment, laser processing, plasma processing, energy beam processing, PVD, CVD, deposition etc.
| Analytical Techniques for surface characterization: X-ray diffraction, TEM, SEM and EDX, WDX analysis. Surface analysis by AES, XPS and SIMS, overview of other techniques. Data interpretation and approaches to materials analysis.

**Essential reading:**

**Supplementary Reading:**

Essential Reading:
2. G. Cao, Nanostructures and Nanomaterials, Imperial College Press, 2006.

Supplementary Reading:

MM 4206 METALLURGICAL FAILURES: DETECTION AND ANALYSIS 3-0-0 3

Non-destructive testing of defects: visual inspection, liquid penetration inspection, magnetic particle inspection, eddy current inspection, ultrasonic testing, radiographic inspection.
Phenomenological description of various modes of failure, fracture, fractography
Different failures: Fatigue failure, creep and stress rupture failures, environment-assisted failures, wear failures, common failures in castings, weldments, gears, shafts and springs, failures of composites
Analyses of engineering failures: Typical defects, macroscopic fracture surface examination, metallographic and fractographic examination, steps in failure analysis, case histories.

Essential Reading:

Supplementary Reading:
2. D. Broek, Elementary Fracture Mechanics, Martinus Nijho Publisher.

MM 5510 ADVANCED PROCESSING OF MATERIALS 3-0-0 3
Rapid solidification, Powder processing, Preparation and consolidation of nanopowders, Sintering, Spark Plasma and Microwave sintering, Shock compaction, Severe plastic deformation, Mechanical Alloying, near-net-shape forming, self-sustaining high temperature synthesis, sol-gel processing, zone refining, molecular beam epitaxy, laser processing, EDM, etching, CMP (Chemical Mechanical Polishing) technology Freezecasting, glass-ceramic seals, optical/photonic media, hybrid materials, solution-derived materials, solid oxide fuel cells, armor ceramics, Processing and manufacturing technologies for non-oxide and oxide based structural ceramics, composites, multifunctional materials. Stereolithography (SLA), selective laser sintering (SLS), direct metal laser sintering (DMLS) and laser engineered net shaping (LENS), Spray formed tooling for rapid manufacture, Plasma spray coating. Preparation of single crystals, doping, sputter coating, CVD and EVD process, Inkjet printing as a manufacturing tool. Modelling, commercial softwares such as FLUENT and ComsolMultiphysics.

**Essential Reading:**

**Supplementary Reading:**

| MM 5511    | Texture of Materials | 3-0-0 | 3 |

Concept of texture in materials, Texture representation by pole figure and orientation distribution functions, Texture measurement by different techniques: X-ray diffraction (XRD) and Electron backscattered diffraction (EBSD).

Origin and development of textures during materials processing stages: solidification, deformation, annealing, phase transformation, coating processes and thin film deposition. Some important textures in fcc, bcc and hcp materials. Influence of texture on mechanical and physical properties of materials.

**Essential reading:**

Alternative Routes of Iron Making

Need for alternative iron making units; Different categories of alternative routes and their salient features; Special features of low shaft and mini blast furnaces and their future.
Coal based direct reduction process during rotary kilns (SL/RN, CODIR, ACCAR, etc.) – operational features, raw material characteristics, strengths and weaknesses, etc; Gas based direct reduction processes (HYL, MIDREX, Fluidized Bed, etc.) – principles, essential features and characteristics; Characteristics of DRI produced from these DR processes and its uses; Future of DR processes in India; Electro-thermal smelting processes – special features, operation, quality of reductant and limitations; Smelting reduction processes - activities, operational details and characteristics of processes like COREX, INRED, ELRED etc; Future of SR processes.

Essential Books:
1. Amit Chatterjee, Sponge iron production by direct reduction of iron oxide, PHI, New Delhi, 2010.

Alloy Steel Technology

Production Technology ; Electric arc furnace: Design, Construction and operation, Refractory lining, Electrode movement and slag control, Manufacture of alloy steels such as low alloy steels, stainless steels, Tool steels and silicon steels. ; Induction melting furnace: Classification, Construction and Refractory lining, Operation and manufacture of alloy steels. ; Processing, microstructure & mechanical properties of different alloy steels such as HSLA steels, Dual phase steels, IF steels, stainless steels, silicon steels, high speed steels, ball bearing steels, Had field steels etc.

Essential Reading:

Supplementary Reading:
1. G.Karuss, Steel Heat Treatments and Processing Principles, ASM.

Experimental Techniques in Materials Engineering

X-ray and diffraction: Characterization of x-rays, absorption, x-ray diffraction techniques, interpretation of diffraction datas, qualitative and quantitative phase analysis, analysis of particle size, residual stress/strain, phase diagram determination, order disorder transformation study. ; X-ray fluorescence: Origin, basic theory/concept, characterization of materials through x-ray fluorescence. ; Electron microscopy: TEM & SEM, construction, different components & their functions, aberration of electron lenses, depth of field & depth of focus etc. Bright field & dark field image, SAD image etc., microprobe analysis. ; WDS & EDS: Principle, application for analytical studies. ; Spectroscopic analysis techniques: Fundamental principles of spectroscopy, origin of molecular & atomic spectra, atomic absorption & molecular absorption. ; Fundamentals of Flame emission & atomic absorption spectrometry: Flame emission spectroscopy & Flame spectra, chemical reaction in flames, effect of organic solvants on flame spectra, instrumentation, Photosensitive detectors, different methods of sample analysis, errors
in flame photometry; Absorption spectroscopy: Infrared spectroscopy, FTIR (Fourier transform infrared spectroscopy) nuclear magnetic resonance (NMR) spectral analysis; Atomic emission spectroscopy: Emission sources, atomic emission spectrometers; Thermal analysis techniques: Thermo gravimetric analysis, differential thermal analysis and differential scanning calorimetry, the basis, instrumentation, data acquisition and interpretation of analytical results.

**Essential Reading:**

**Supplementary Reading:**

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**MM 5403 Process Modeling for Steel Industry**

| 3-0-0 | 3 |

Basic terms of process modeling, Physical modeling and its importance in various fields of science; System similarity and similarity constants (dimension less numbers); Geometric, kinematic and dynamic similarity; The principles for construction of physical models: Basic experimental techniques in physical modeling of flow of liquid metals; Significance of CFD in steel technology; Identification of governing differential equation for fluid dynamics; Initial and boundary conditions; Finite difference method - central, forward, backward difference; Control volume formulation; Steady state heat conduction modeling; Unsteady heat conduction formulation; Source term linearization; Steady one dimensional convection and diffusion modeling - up wind scheme, exponential scheme, hybrid scheme, power-law scheme; False diffusion; Simple algorithm; Simple-R algorithm; Mathematical models of turbulence; The selection of suitable mathematical models to describe transient metallurgical processes; Charge calculation for heat in LD converter; Static and dynamic model of heat management in basic oxygen steel making process; Introduction to ANSYS fluent 14.0 software package; Applications of CFD Modeling in Iron Making and Steel making Process (some examples based on relevant case studies);

**Essential Reading:**
## Minor Course

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM 2108</td>
<td>Structure and Properties of Materials</td>
<td>3-0-0</td>
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</table>


### Essential Reading:


### Supplementary Reading:


<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM 2308</td>
<td>Iron and Steel Making</td>
<td>3-0-0</td>
</tr>
</tbody>
</table>

Introduction, Blast Furnace Route for Iron Making; The Blast Furnace and its accessories, The burden and its preparation, Physical – Thermal and Chemical process in a Blast Furnace, Blast Furnace slag and its control, Control of hot metal composition, Blast Furnace plant and accessories, Modern trends in Blast Furnace practice, Control of irregularities in the blast furnace, Performance of Blast Furnace over the years.

Alternative Methods: Need for alternative Methods, Sponge Iron production by using solid and gaseous reductants, Smelting Reduction Processes.


Casting of liquid steel: Ingot Casting of Steel, Continuous Casting of Steel. Iron and Steel Scenario in India in the last decade.

### Essential Readings:


### Suggested Readings


<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<th>Hours</th>
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<tr>
<td>MM 3109</td>
<td>Fundamentals of Physical Metallurgy</td>
<td>3-0-0</td>
<td>3</td>
</tr>
</tbody>
</table>

Concept of phase, phase transformation and types of phase transformation. Allotropy of Iron and Fe-C system, types of steels, TTT and CCT Diagrams, Functions of alloying elements in steel, basics of Pearlitic, Bainitic and Martensitic Transformations. Formation of Austenite, Importance of Austenite Grain size.

Pearlitic transformation: Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth.

Bainitic transformation: Mechanism of transformation, Nucleation and growth, Orientation relationships, Surface relief.

Martensitic transformation: Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography.


Age hardening: mechanism and elated heat treatment.

**Essential Reading:**

**Supplementary Reading:**

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<tr>
<td>MM 3207</td>
<td>Mechanical Metallurgy</td>
<td>3-0-0</td>
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</table>

**Basic Elasticity and Plasticity** – Definition of stress and strain, stress and strain tensor, Hooke’s law, Poisson’s ratio, plane stress and plane strain condition, yield criterion: von Mises and Tresca, yield locus, flow rule.

**Dislocation Mechanisms** – Introduction to dislocations in crystalline materials, edge, screw and mixed dislocations, Burgers vector, slip system, cross slip and climb.

**Hardness**- Different types like Brinell, Rockwell, Vickers, Meyer, Knoop, etc., relationship with flow behavior.

**Tensile** – Engineering and true stress-strain curves, evaluation of tensile properties, tensile instability, strain hardening exponent, effect of strain-rate and temperature on flow properties.

**Compression** – Comparison with tension, standard test procedure, phenomenon of buckling & barreling.

**Impact** – Notched bar Charpy and Izod impact tests, concept of transition temperature, metallurgical factors affecting impact toughness, instrumented impact test.

**Creep** – Creep and stress rupture tests, mechanisms of creep deformation, deformation mechanism maps, development of high temperature alloys.

Fracture and Fracture Mechanics – Brittle and ductile fracture, Griffith criterion and Orowan’s rule, energy based criterion, strain energy release rate, stress intensity factor, plastic zone, plane strain fracture toughness estimation.

Non Destructive Testing – Significance of non-destructive testing, different methods and their principles.

Essential reading:
1. Mechanical Metallurgy by G. E. Dieter
3. Practical Non Destructive Testing by Baldev Raj

Supplementary reading:
1. Mechanical Behaviour of Materials by Courtney
2. Mechanical Behaviour of Materials by M. A. Meyers and K. K. Chawla
3. Mechanical Testing of Metals, ASM handbook

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<tbody>
<tr>
<td>MM 4512</td>
<td>Materials Characterization Techniques</td>
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</table>

Optical Microscopy and Image analyzer: Understanding of image formation, resolution, numerical aperture, magnification, depth of field and depth of focus of a microscope. Quantitative and phase analysis (inclusion, size distribution etc.). X-ray diffraction and analysis: Production and properties of X-rays, X-ray diffraction, Structure factor and intensity calculations. Effect of texture, particle size, micro strain on diffraction lines. Indexing of powder photographs. X-rays florescence: basics and applications in materials science.


DTA/DSC-TG: Scope and applications in materials science.

Essential Readings
Suggested Readings


Electro winning of Cu from acidified CuSO₄ solution; Electro winning of Zn from SnSO₄ solution; Electro deposition of Cu on mild steel electrode from acid bath; Electro deposition of Cu on mild steel electrode from an alkaline bath; Deposition of Nickel on Cu plate by electro plating and thickness determination of deposit by BNF Jet test; Determination of throwing power and throwing efficiency of alkaline Cu plating solution; Monitoring of corrosion rate of mild steel; Anodisation of given Aluminium rods; Electro deposition of Brass on mild steel plate from cyanide bath.

To determine the tumbler and abrasion indices of lump iron ore; To determine the micuum indices of coke; To study the decomposition of calcium carbonate and determination of equilibrium constant and free energy change; To determine the partial molal volume of each component in a solution of water and methanol; To determine the equilibrium constant and free energy change for the \( \text{C} + \text{CO}_2 \rightleftharpoons 2 \text{CO} \) reaction; To study the effect of temperature on % reduction of iron ore pellet; To study the effect of time on % reduction of iron ore pellet; Pelletization of iron ore fines, firing of pellets and measurement of their crushing strengths.

General introduction of solid fuels; To determination % moisture and volatile matter contents in coal; To determine the % ash and fixed carbon contents in coal; To determine calorific value of coal; To determine bulk density of coal – study of the effects of size and moisture addition; To determine apparent density and apparent porosity of coal/ coke; To determine true density and true porosity of coal; To determine caking index of coal; To determine the % yield of char on carbonization of non – coking coal.

Analysis of diffractographs of FCC and BCC metals & Study of diffractographs of mechanical mixture & alloys of same composition; High temperature microscopic study of: Ceramic material, Metallic material; Topological and elemental analysis of metallic sample by SEM; Study of particle size analysis; To carry out the thermal analysis of Al sample using TG – DSC technique (Melting point and oxidation study); Dilatometric study of given Al plate sample; Thermal analysis of different grade carbon steel using DSC – TG technique to study Microstructural changes with temperature; Thermal analysis of epoxy polymer using DSC technique (glass transition temperature)
### MM 3121 | Metallography Laboratory | 0-0-3 | 2

Preparation and practice of metallographic specimen; Study of microstructure of pure metals like Al, Cu, Study of microstructure of common alloys like Brass, brass, Al-Bronz, Muntz metal; Study of microstructure of eutectic and eutectoid alloys; Study of microstructure of 0.2, 0.6 and 1.1 %C steel in annealed condition; Study of microstructure of gray, white and malleable cast iron.

### MM 3421 | Computational Metallurgy Lab. | 0-0-2 | 1

Basics of numerical mathematics, Concept of physical domain and computational domain numerical, Integration, Initial value problems, assumptions and limitations in numerical solutions, simulation, instrumentation and data acquisition systems. ; To draw a circle using MATLAB ; To solve a system of linear equations using MATLAB ; To solve an ODE using MATLAB ; To find out the standard deviation of a given set of values using MATLAB ; Curve fitting techniques using regression and interpolation. Using MATLAB fit a linear curve for given set of data ; To draw a sphere using MATLAB and extend the program to draw FCC and BCC crystal structures ; To find out the lattice parameter from the XRD data of an element belonging to the cubic system using MATLAB ; To create your own design using MATLAB codes.

### MM 3122 | Heat Treatment Lab. | 0-0-2 | 1

Primary calibration of thermocouple and measurement of melting point of a metal; annealing, normalizing and hardening of different types of steel; Study of microstructures and hardness of heat treated steels obtained from earlier experiment; Carburization of low carbon steel and microstructural study; Jominy End quench test; Study the age hardening behaviour of 2XXX / 7XXX aluminium alloy ; Annealing of cold worked metal and study the changes in microstructures

### MM 3221 | Mechanical Testing Lab. | 0-0-2 | 1

Hardness measurement of metallic materials using Vicker, Rockwell and Brinell hardness testing machines ; Microhardness testing of two and / or multiphase alloy systems ; Tensile tests of low carbon steel (annealed), high carbon steel (annealed) and a non ferrous alloy ; To draw true stress – true strain diagram/s using above data and determination of strain hardening exponent ; Compression testing of ceramics, powder metallurgy specimens ; Three – point bend test of non – metallic materials ; Impact testing of steels / non – ferrous alloys / non – metallic materials ; Wear studies of different carbon steels ; To develop S – N curve of a metallic specimen ; KIC tests of a brittle material.

### MM 4521 | Electro Metallurgy & Corrosion Lab. | 0-0-2 | 1

Electro winning of Cu from acidified CuSO₄ solution ; Electro winning of Zn from SnSO₄ solution ; Electro deposition of Cu on mild steel electrode from acid bath ; Electro deposition of Cu on mild steel electrode from an alkaline bath ; Deposition of Nickel on Cu plate by electro plating and thickness determination of deposit by BNF Jet test ; Determination of throwing power and throwing efficiency of alkaline Cu plating solution ; Monitoring of corrosion rate of mild steel ;
Anodisation of given Aluminium rods ; Electro deposition of Brass on mild steel plate from cyanide bath.

<table>
<thead>
<tr>
<th>MM 4422</th>
<th>Design &amp; Calculation Lab.</th>
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Design of Blast Furnace ; Blast Furnace charge calculation; Heat balance of Iron Blast Furnace ; Heat balance of Blast Furnace Stove ; RAFT (Raceway Adiabatic Flame Temperature) Calculation ; Design of a L.D. Vessel ; Heat balance of a Composite Steel Slab Reheating Furnace ; Calculation the thickness of the solidified shell at the mould exit in a Continuous Casting Unit.

<table>
<thead>
<tr>
<th>MM 4423</th>
<th>Atomistic Modelling of Materials Lab.</th>
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</table>

Creation BCC and FCC lattice by LAMMPS; Melting simulation of pure Cu by LAMMPS; Melting simulation of Cu-Al alloy by LAMMPS; Rapid solidification simulation of Cu-Zr alloy by LAMMPS; Structure studies of crystalline, liquid and amorphous materials by LAMMPS; Simulation of synthesis of glass-matrix composite by LAMMPS

Lab for Minor Course

<table>
<thead>
<tr>
<th>MM 4123</th>
<th>Physical Metallurgy Lab.</th>
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Preparation and practice of metallographic specimen; Study of microstructure of pure metals like Al, Cu, Study of microstructure of common alloys like □- Brass, □□□ brass, Al-Bronz, Muntz metal; Study of microstructure of eutectic and eutectoid alloys; Study of microstructure of 0.2, 0.6 and 1.1 %C steel in annealed condition; Study of microstructure of gray, white and malleable cast iron.

Primary calibration of thermocouple and measurement of melting point of a metal; annealing, normalizing and hardening of different types of steel; Study of microstructures and hardness of heat treated steels obtained from earlier experiment; Carburetion of low carbon steel and microstructural study; Jominy End quench test; Study the age hardening behaviour of 2XXX / 7XXX aluminium alloy; Annealing of cold worked metal and study the changes in microstructures.

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Hardness measurement of metallic materials using Vicker, Rockwell and Brinell hardness testing machines ; Microhardness testing of two and / or multiphase alloy systems ; Tensile tests of low carbon steel (annealed), high carbon steel (annealed) and a non-ferrous alloy; To draw true stress – true strain diagram/s using above data and determination of strain hardening exponent; Three – point bend test of non – metallic materials; Impact testing of steels / non – ferrous alloys / non – metallic materials ; Wear studies of different carbon steels; To develop S – N curve of a metallic specimen; KIC tests of a brittle material.

DEPARTMENT OF MINING ENGINEERING

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**MINE DEVELOPMENT**

I. Pre-requisites: Under graduate Physics and Maths.

ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: Introduction: Distribution of mineral deposits in India and other countries, mining contributions to civilization, mining terminology,

Module 2: stages in the life of the mine - prospecting, exploration, development, exploitation and reclamation,

Module 3: access to mineral deposit- selection, location, size and shape (incline, shaft and
adit), brief overview of underground and surface mining methods.

Module 4: Drilling: Types of drills, drilling methods, electric, pneumatic and hydraulic drills, drill steels and bits, drilling rigs, and jumbos;

Module 5: Explosives: Classification, composition, properties and tests, fuses, detonators, blasting devices and accessories, substitutes for explosives, handling and storage, transportation of explosives.; Rock blasting: Mechanism of rock blasting, blasting procedure, and pattern of shot holes.

Module 6: Shaft sinking: Ordinary and special methods, problems, and precautions, shaft supports and lining.

Course Outcome:
CO1: To understand the distribution of mineral deposits, and mining terminology
CO 2: To introduce different types of mining methods available for exploitation of mineral deposits
CO3: Analyze design requirement of approach to mineral deposits

Essential Reading:

Supplementary Reading:

MINE SURVEYING

i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining and Civil Engg.,
iii. Modules:
Module1: Linear measurement, Compass surveying – use of prismatic compass, bearing of a line, dial traverse and adjustments, local attractions and correction of bearings.

Module 2: Theodolites- seconds theodolites, micro-optic theodolites, electronic theodolites, measurement of horizontal angles by repetition method and re-iteration method and measurement of vertical angles by general method.

Module 3: Traversing – surface and underground including boundary surveys and joint surveys, survey errors and their adjustments, co-ordinate calculations.

Module 4: Leveling- use of dumpy levels, quick setting levels, digital levels and leveling staff, temporary adjustments of levels, ordinary and precise leveling, reduction of levels by height of instrument method and rise and fall method, reciprocal leveling, profile leveling, differential leveling.

Module 5: Triangulation: Classification of Triangulation systems, Triangulation figures, Base line measurements; Correlation of surface and underground surveys: Verticality of shafts, measurement of depth of shafts; Setting out curves – surface and underground.

Module 6: Special Mine Surveys: Surveys for connecting national grid, survey of installations of mine structures, EDM and its application, Surveying by Modern instruments by using GPS & Total Station.

Course Outcome:
CO1: Introduction to measuring techniques in surveying along with instruments
CO2: To familiarize with underground and surface surveying in mines
CO3: To apply modern instruments for mine surveying

**Essential Reading:**

**Supplementary Reading:**
1. V. Maslov, Geodetic Surveying, Mir Publication, Moscow, Revised edition, 1980

**MINING MACHINERY**

i. Pre-requisites: Undergraduate Physics and Mathematics

ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: General: Mechanical transmission of power in mining machinery, shafts, pulleys, gears, and gear/trains, belt drives, chain drives, couplings and clutches, brakes.

Wire ropes: Constructions, examinations, listing and maintenance.

Module 2: Rope and locomotive haulages: Direct, main and tail, balanced double drum and endless haulage, gravity haulage, constructional features, power calculation, selection of haulage ropes, haulage tracks and safety appliances, tubs and mine cars, diesel, battery and trolley wire locomotives, tractive effort, ideal gradient, power calculations, exhaust conditioners.

Module 3: Compressors and pumps: Generation, distribution and use of compressed air in mines, mine pumps, pumping ranges, and fittings.

Module 4: Cutting and mining machines for coal/ore, surface coal/ore handling plant.

**Course Outcome:**

CO1: To understand the concept of underground transport system
CO2: Application and features of cutting and mining machines
CO3: To enhance the knowledge of mechanical transmission of power, compressor and pumps used in mines

**Essential Reading:**

**Supplementary Reading:**

**MINERAL EXPLORATION**

i. Pre-requisites: Undergraduate Physics and Chemistry

ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: Classification of ore reserves: proved, probable, and geologist’s ore. Geological aspects of drilling borehole location, planning of drilling operations, borehole surveys, correction of deviated boreholes and directional drilling, core-sampling and assaying;
Module 2: Economic classification of mineral resources: calculation of in-situ reserves from borehole data. Underground sampling and calculation of blocked reserves;


Course Outcome:
By the end of this course, students will be able to:
CO1: Understand ore reserve and different sampling methods from exploration study
CO2: Understand the theories of different mineral explorations
CO3: Know how the mineral resources are explored in real deposit by different exploration techniques

Essential Reading:

Supplementary Reading:

MINING GEOLOGY

i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Mining Engg.
iii. Modules:

Module 1: Introduction to Geology: its scope and application to engineering problems, Physical Geology, Mineralogy - Determinative properties and occurrence of common rock forming minerals in India,

Module 2: Petrology - Igneous, Sedimentary and Metamorphic rocks; Structural Geology: Elementary knowledge of rock deformation and structural characteristics of deformed rocks, strike, dip, folds and faults, their description, classification, Joints, Un-conformities/simple forms of igneous rocks, Dykes, sills, etc., Geological maps and their interpretation,

Module 3: Stratigraphy - Principles of Stratigraphy, Standard Stratigraphic Scale, Indian Stratigraphy; Economic minerals: their classification, origin, mode of occurrence, geographical and geological distribution,

Module 4: physical properties and industrial uses and distribution of major metallic and non-metallic mineral deposits of India.

Module 5: Origin and distribution of natural fuels - Coal, Petroleum and natural gas, nuclear fuels.

Course Outcome:
By the end of this course, students will be able to:
CO1: Understand the formation of different rocks and their properties
CO2: Correlate the stratigraphy with localization of different mineral deposit
CO3: Know the distribution of different minerals in India and their origin

Essential Reading:
Supplementary Reading:

GEOSTATISTICS

i. Pre-requisites: Under graduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:
   Module 1: Expectation; Spatial Description: Contour maps, Indicator maps, Moving window statistics, Proportional effect, Spatial continuity, h-scatter plots, correlation functions, covariance function and variograms, cross h-scatter plots; Random function,
   Module 2: From statistics to Geostatistics, Modeling sample variograms, Regionalized variables; Global estimation: Polygonal declustering, cell declustering, comparison of declustering methods; Point estimation: Polygon, triangulation, inverse distance methods, search neighborhoods;
   Module 3: Kriging: Ordinary kriging, simple kriging; Block Kriging; Search strategy; cross validation; Variance volume relationships;
   Module 4: change of support: Practical importance of support effects, effect of support on summery statistics, correcting for support effect, transforming from one distribution to another, affine correction, indirect lognormal correction, dispersion variance, estimating dispersion variance from a variogram model; assessing uncertainty;
   Module 5: Multivariate geostatistics, Geostatistics for quality control, grade tonnage curve, Basics of non-parametric geostatistics, Indicator Kriging, Brief idea about geostatistical simulation, Introduction to GEOFES/ GSLIB/SURPAC software.

Course Outcome:
By the end of this course, students will be able to:
CO1: Investigate various spatial interpolation methods
CO2: Understand the nature and access local influence in spatial modeling
CO3: Understand how spatial autocorrelation can be used to model mineral resources

Essential Reading:

Supplementary Reading:

MINE SURVEYING LABORATORY 2 credits [0-0-3]
Prismatic Compass Surveying: (a) Bearing of the lines (b) Traversing; Leveling: (a) Precise Leveling (b) Profile Leveling; Plane Table Surveying: (a) Intersection Method (b) Radiation Method; Theodolite Traversing; Theodolite: (a) Horizontal angle measurement (b) Vertical angle measurement; Signs and Conventions used by the GSI, MMR and CMR; Triangulation Survey: (a) By 1” Theodolite (b) By Electronic Theodolite; Triangulation Survey (a) By EDM (b) By Total Station; Distance Measurement: (a) By EDM (b) By Total Station; Coordinate Measurement: (a) By Total Station (b) By GPS; Traversing and Recording Position of points by GPS; Special Mine Surveys – Surveys for connecting National Grid, Survey of installations of Mine Structures

MINING GEOLOGY & EXPLORATION LABORATORY  2 credits  [0-0-3]

Identification of common rocks; Identification of common Minerals; Study of physical properties of minerals; Determination of strike and dip; Identification and stereographic plotting of joints; Study of topographic maps; Drawing of geological section; Geological maps with folds and faults; Study of geophysical exploration equipment - resistivity meter; Study of aquameter; Study of magnetometer; Geological field trips

MINING MACHINERY LABORATORY  2 credits  [0-0-3]

Study of jack hammer drill; Study of different types of wire rope & their uses; Study of different types of rope clips; Study of reliance rope capel; Study of different types of roof bolts; Study of Sylvester prop withdrawar; Study of different types of brakes; Study of different types of Clutches; Study of different parts & functions of an electric coal drill; Study of direct rope haulage; Study of endless rope haulage; Study of main & tail rope haulage.

SYSTEMS ENGINEERING

i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining Engg.
iii. Modules:

Module 1: Introduction: Concept of systems engineering, general model selection; Data collection: Data collection methods, time study, work sampling, sample number calculation; System analytical techniques: Statistical methods, control charts – X bar chart, R chart, S chart; Mathematical methods for loading and hauling;

Module 2: Stochastic models: Monte Carlo simulation, Activity oriented simulation, process oriented simulation; Reliability: Concepts of reliability, concept of different distribution: Normal, exponential, Beta, Gamma, Binomial, lognormal etc.; fitting a distribution to data, reliability of series and parallel systems, reliability analysis of a combined series parallel system; Optimization and design: Heuristic technique, Dynamic programming, network flow theory, Graph theory;

Module 3: Programming: Linear programming, transportation and assignment problems, Mixed integer linear programming, queuing theory, network analysis, inventory control and simulation techniques.

Module 4: Analysis: Analysis of exploration and mining systems using mathematical programming, simulation techniques and network models; stochastic model simulation; Concept of Artificial Intelligence: Natural language understanding, Machine vision, robotics, expert system.

Course Outcome:
By the end of this course, students will be able to:
CO1: Formulate the real life system optimization problems into mathematical models
CO2: Solve the mathematical models using operation research techniques
CO3: Incorporate the uncertainty of the mining systems parameters in optimization model

Essential Reading:
2. N. Deo, System Simulation by Digital Computers, Prentice Hall of India, 2005
MINE ECONOMICS

i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining Engg.
iii. Modules:
  Module1: Examination of Mineral properties, Mine sampling, estimation of reserves and grades, Impurities and quality control, commercial uses of minerals and ores;
  Module 2: Mine valuation. Depreciation methods; decision trees, Mineral Industry of India,;
    National Mineral Policies, conservation, taxation, trading, mining entrepreneurship,
    Principles of company law, shares and debentures;
  Module 3: joint stock company and public company; partnership business, capital formation,
    Cost-Volume-Profit analysis and break-even analysis, budgetary control, wages and incentives, purchases, stores and inventory control, sales and dispatches.

Course Outcome:
CO1: To understand the procedures for estimation of reserves and grades
CO2: To introduce mining entrepreneurship, Principles of company law etc for mine valuation
CO3: To enhance the knowledge related to wages and incentives, purchases, stores and inventory control etc.

Essential Reading:

Supplementary Reading:
1. O. P. Khanna, Industrial Engineering and Management, Dhanpat Rai Delhi, 1993
2. R. N. P. Arogyaswamy, Courses in Mining Geology, Oxford and IBH Pub., 2nd Ed, 1973

MATERIAL HANDLING SYSTEMS

i. Pre-requisites: Under graduate Mining machinery and Mine development
ii. Target Departments: Mining Engg.
iii. Modules:
  Module1: Mine hoist: Drum and koepe winders, constructional features, kinematics, torque and power calculation, speed control, safety contrivances, selection of mine winders, cages, skip, suspension gears, headgear structures, cage guides, pit top and pit bottom circuits and layouts;
  Module 2: Conveyors: Belt conveyor, chain conveyor, cable belt conveyor, shaker conveyor, vibratory conveyor, constructional features and power calculations, selection and application;
  Module 3: Aerial Ropeway: Mono-cable, bi-cable, twin-cable ropeway, constructional features and power calculations, selection and application;
  Module 4: Scraper Haulage: Constructional features, applicability, advantages and disadvantages;
  Module 5: Men and material transportation: Trackless vehicle loaders, shuttle cars, SDL and LHD, special men and materials transport in mines, men riding systems in mines.;

Course Outcome:
CO1: Design and application of hoisting system
CO2: Application of men and material transport system
CO3: To enhance the knowledge and design concept of scraper haulage, aerial ropeway and belt conveyor system in mines.

Essential Reading:
Supplementary Reading:
4. B. Norman, Mechanics of bulk material handling, London Butterworths, 1st Ed, 1971

COMPUTER APPLICATION IN MINING

i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: Introduction to structure terminology and peripherals, algorithms, flow charts, programs, dedicated systems. Application in Mining: Exploration, rock topographic models, bore hole compositing, compositing, ore reserve calculation, interpolation and geostatistical models.

Module 2: Open pit design: Ultimate pit design, introductory process control, underground mine design: Production scheduling; Operation Simulation: Introduction, Simulation overview, objective, understand the role of modeling, Understanding the basic concept in simulation

Module 3: Example of simulation in mining aspects: Simulation of machine repair problems, Concepts of variability and prediction, Example with dumping time problem, fitting distribution with chi-square test

Module 4: Random number generation: Methods of random number generation, Properties of random number, pseudorandom number; Random variates generation: Methods of random variates generation, inverse transformed method, acceptance rejection method, composition method, empirical method and rectangular approximation

Module 5: Simulation languages: GPSS, SLAM; Logical flow diagram of different mining activities, Coding with GPSS and SLAM of different mining problems; Computer Control: Remote control, automatic control, application and limitations of control.

Course Outcome:
By the end of this course, students will be able to:
CO1: Formulate the mining problem in computer readable language (pseudocode/flowchart)
CO2: Simulate small scale mining systems
CO3: Generate random numbers and understand the use of them

Essential Reading:

Supplementary Reading:
1. R. V. Ramani, Application of computer methods in the mineral industry

MINERAL PROCESSING TECHNOLOGY

i. Pre-requisites: Under graduate Physics, Mathmatics and Chemistry
ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: General Principle: Mineral Beneficiation and its role in mineral Exploitation; Comminution and Liberation: Theory and practice of crushing and grinding, performance and choice of crushers and grinding mills. Laboratory techniques, interpretation and plotting of data, Industrial screens and screening efficiency;

Module 2: concentration: Theory and practice of classification, Classifiers- their performance and choice, Picking and washing techniques. Theory and application of sink and float, jigging and flowing film concentration- methods and equipment used;
Module 3: Froth Flotation: Physico-chemical principles, flotation reagents, flotation machines and circuits, application to common sulphides, oxides and oxidized minerals. Electrostatic and Electro-magnetic Separation - Principles, operations and fields of applications;

Module 4: Flow Sheets: Simplified flow sheets for the beneficiation of beach sand, coal and typical ores of copper, lead, zinc and manganese with special reference to Indian deposits.

Course Outcome:
CO1: To understand the Laboratory techniques of Mineral Beneficiation
CO2: To study various methods and equipment used for concentration
CO3: To give exposure to flow sheets for the beneficiation of various ore/minerals with special reference to Indian deposits

Essential Reading:

Supplementary Reading:
2. B. A. Wills, Mineral Processing Technology, Willy & Sons, 2005

SURFACE MINING TECHNOLOGY
i. Pre-requisites: Undergraduate Physics and Mathematics
ii. Target Departments: Mining Engg.
iii. Modules:
Module 1: Introduction: Applicability and limitations, Stripping Ratio, Preliminary evaluation of surface mining projects.

Module 2: Surface Mining Methods: Development of Mineral deposits by opencast mining, design and layout of opencast mines. Methods of stripping, Bench geometry, Bench slope. Drilling, blasting, loading and transportation in opencast mines, Equipment used for different operations, Choice and their application;

Module 3: Placer Mining and Sea bed Mining: Ground sluicing, Hydraulicking and Dredging. Exploitation systems of ocean mineral resources. Relevant provisions of coal mines and metalliferous mines regulations;

Module 4: Environmental problems due to surface mining and their remedial measures, Recent developments in the deployment of heavy earth moving machineries in the surface mines.

Course Outcome:
CO1: To understand the various methods of surface mining
CO2: To apply design principles for stable benches and overall pit slope
CO3: To familiarize with different equipment for surface mining
CO4: To understand impact of surface mining on environment

Essential Reading:

Supplementary Reading:
2. V. V. Rzhevsky, Opencast Mining Unit operations, Mir Pub., Moscow, 1985.

UNDERGROUND MINING TECHNOLOGY
i. Pre-requisites: Undergraduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:

Module 1: Development of Stratified Deposits: Choice of mine size, methods of entry and primary development

Module 2: Underground Coal Mining Methods: Classification and choice, Bord and Pillar mining, development and extraction, Long-wall mining, face mechanization, production equipment and face machinery used, viz. coal cutting machines, drills, mechanical loaders, LHDS, shuttle car etc. – their performance and choice. Special coal mining methods; Provision of CMR 1957

Module 3: Underground Metal Mining Methods: General Development of property level, crosscuts, raises and winzes, drifting and tunneling, U/g metalliferous mining methods – their classification and choice. Stopping of ore bodies, supporting and development of stopes, Special techniques of mining mechanization, mining equipment and production machine used below ground, Provision of MMR 1961

Module 4: Supports: Roadway and face supports, supports for junctions and special conditions, setting and withdrawal of supports, roof bolting, roof stitching, systematic supporting, protective of pillars.

Module 5: Stowing and Filling Methods, gathering and transportation arrangements, stowing plants and layout.

Course Outcome:
CO1: to understand the details of development of a mine for exploitation of mineral deposits
CO2: Analyze design requirements of Underground Coal and metal Mining Methods
CO3: Apply different support systems including backfilling techniques for underground mines for stability of workings

Essential Reading:
1. T. N. Singh, Underground winning of Coal, Oxford and IBH New Delhi, 1992
2. Y. P. Chacharkar, A study of Metalliferous Mining Methods, Lovely Prakshan, Dhanbad, 1994

Supplementary Reading:
1. I. C. F. Statham, Coal Mining Practice, Caxton eastern agencies, Calcutta, Reprint, 1964
3. S. K. Das, Modern Coal Mining Technology, Lovely Prakshan, Dhanbad, 1992
4. R. D. Singh, Principles & Practices of Modern Coal Mining, New age international New Delhi, 1997

ROCK MECHANICS

i. Pre-requisites: Undergraduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:

Module 1: Introduction: Introduction to Geotechnical Engineering, Soil and rock characterization;

Module 2: Physico-mechanical properties: Physical and mechanical properties including swelling potential, different strength parameters and their determination, Hydraulic properties of rocks and determination;

Module 3: Rock Stress: Stresses around mine openings of different cross-sections,

Module 4: Elastic and Time dependent properties of rock: Rock Deformability and its measurement. Elastic and non-elastic behavior, influence of time on rock properties;
Theories of rock failure: Rock Strength, Analysis of Stress-Strain Curve, Rock failure and different failure criteria. Effect of anisotropy on rock strength;

Module 5: Stress: Stress and strain in two and three dimension, Stress-Strain relationships, Mohr’s circle.

Course Outcome:
CO1: To introduce geotechnical Engineering, and properties of rocks/soils
CO2: To study behavior of rocks in various underground structures including fairlure criteria

Essential Reading:

Supplementary Reading:
3. L. Hartman, Mining Engineering Handbook, Society for Mining, Mettalurgy and Exploration Inc., USA, 1992

Geo MECHANICS
i. Pre-requisites: Rock mechanics
ii. Target Departments: Mining Engg.
iii. Modules:
   Module1: In-situ Stress- Determination of in-situ rock mass properties, in-situ testing methods and instrumentations.

Module 2: Design of underground workings: Pillar Design including applicability of Wilson’s approach, Safety factors;

Module 3: Slope Stability: Slope failure types, mechanisms and theories.;

Module 4: Rock Reinforcement and Support: Mechanisms of failure in rock structures-intact and anisotropy, Rock Load and stability, Supporting and reinforcement members, Design of support and reinforcement systems; Surface Subsidence: Subsidence mechanisms and control measures, Basics of numerical methods in geomechanics and applications.

Module 5: Rock mass classification Systems and their interpretation.

Course Outcome:
CO1: To explain the advanced trends in determination of in situ rock mass properties
CO2: To study slope stability and also rock reinforcement techniques for underground and opencast applications

Essential Reading:

Supplementary Reading:
3. L. Hartman, Mining Engineering Handbook, Society for Mining, Mettalurgy and Exploration Inc., USA, 1992
ROCK ENGINEERING

i. Pre-requisites: Under graduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:
Module1: Introduction: Importance of rock mechanics, rock working, judgment and approximation;

Module 2: Ground Characterization: Character of rock materials, rock mass, ground water, stress, site investigation;

Module 3: Rock Excavation and Stabilization: Blasting, drilling, breaking and cutting, rock reinforcement, support and lining systems, drainage and grouting

Module 4: Measurement, Prediction and Monitoring of Rock Behavior: Design Methods, Strength, Deformability, viscous, thermal and swelling behavior, Behavior of discontinuities, Monitoring;

Course Outcome:
CO1: To create awareness on importance of rock mechanics and ground characterization
CO2: To understand various measures for rock Excavation and stabilization including design methods

Essential Reading:

Supplementary Reading:
1. L. Hartman, Mining Engineering Handbook, Society for Mining, Metallurgy and Exploration Inc., USA, 1992

STRATA CONTROL TECHNOLOGY

i. Pre-requisites: Under graduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:
Module1: Geomining conditions: Geological factors contributing to strata control problems in mines, Geomechanics classification of rocks;

Module 2: Safety status: Status of safety in coal mines vis-à-vis strata control problems, Assessing the risk from the hazards of roof & side falls;

Module 3: Design of support system: Design of support system for development and depillaring workings, Design of support system for long wall workings, Application of modeling techniques to strata control problems

Module 4: Strata behavior studies: Instrumentation for evaluation of strata condition in coal mines, Strata control techniques and its application to coal mining industry, Case studies on geotechnical instrumentation and strata control in coal mines, Demonstration of geotechnical instrumentation and computer software;

Module 5: Organization of strata control cell: strata control cell in mines, Training needs of the first line supervisors for effective implementation of the latest strata control technologies.

Course Outcome:
CO1: Identify and understand the factors contributing to strata control problems in mines
CO2: Analyze design requirement of support system in different workings of mines
CO3: Apply different instruments for evaluation of strata condition and organization of strata control cell in mines

**Essential Reading:**

**Supplementary Reading:**

**GROUND CONTROL INSTRUMENTATION**

i. Pre-requisites: Undergraduate Physics and Maths.

ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: Deformation and Strain Measuring Instruments: Convergence meters, convergence recorders, tape extensometers, bore hole deformation, gauge, multipoint borehole extensometers, and bore hole camera.

Module 2: Load and Pressure Measuring Instruments: Load cells, pressure measuring instruments – stress capsules, stress meters, borehole pressure, cells and flat jacks. Strain gauges and transducers, readout units, sensors, transmitters, and data acquisition systems.


Module 4: Applications: Mining Engineering applications: Instrumentation in underground mines and opencast mines; Civil Engineering applications; Instrumentation in Hydroelectric projects and Tunnels, case studies.

Course Outcome:
CO1: To understand details of different Instruments for monitoring ground behavior
CO3: Apply the instruments for different excavations including hydroelectric projects, tunnels etc

**Essential Reading:**

**Supplementary Reading:**

**MINE VENTILATION**

i. Pre-requisites: Undergraduate Physics and Chemistry

ii. Target Departments: Mining Engg.

iii. Modules:

Module 1: Composition of mine air, Mine gases: properties, origin, occurrence, physiological effects, detection, monitoring and control, Methane layering, Degasification of coal seams. Production, assessment, physiological effects and control of mine dusts;

Module 2: Thermal environment and psychrometry: Sources of heat load sources in mines, Effect of heat and humidity on miners. Psychrometry, Cooling power of mine air, Methods of improving of cooling power of mine air, Air Conditioning - basic vapor cycle;
Module 3: Mechanics of air flow through mine openings, Resistance of airways, Equivalent orifice, distribution of air current, control devices in ventilation systems, Natural ventilation: Calculation of NVP, Thermodynamic aspects, Artificial aids to natural ventilation;

Module 4: Mechanical ventilation: Principal types of mine fans, Installation, operation, characteristics and selection of mine fans, Fan testing and Output Control, Fan laws and fan drives, Evases, Diffusers, Booster fans, Auxiliary ventilation. Reversal of air currents and controlled recirculation; Ventilation fans. Ventilation Survey: Quantity and Pressure survey;

Module 5: Planning and Design of Ventilation Systems: mine ventilation design criteria and ventilation design factors, ventilation standards, Ascensional, descensional, homotropal, antitropal, central and boundary ventilation systems, Ventilation layouts for coal and metal mining, Network analysis : Hardy-Cross method, Computer application in mine ventilation.

Course Outcome:
CO1: Comprehend and analyze the occurrence of mine gases, dusts and methane drainage and be able to develop and explain control strategies
CO2: Comprehend and explain the principles and control of heat and humidity behavior in underground airways
CO3: Apply the principles of air flow in an underground mine ventilation system
CO4: Comprehend the principles of mine fan selection in order to evaluate the selection and produce improved solutions
CO5: Comprehend natural ventilation and explain its application underground.
CO6: Carry out ventilation survey.
CO7: Plan and Design a basic underground mine ventilation systems.
CO8: Comprehend and be able to solve simple ventilation network problems.

Essential Reading:
2. G. B. Mishra, Mine Environment and Ventilation, Oxford University Press, Fifth Impression, 1993

Supplementary Reading:

SOLID FUEL TECHNOLOGY

i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Mining Engg.
iii. Modules:
Module1: Introduction: Processes of formation of coal, Theories of origin of coal, Eras of coal formation, Indian Coalfields and its subsidiaries: Occurrence and distribution, coal bearing formations, coal type and rank variation, Characteristics of major coalfields, Coal production from different sectors.;

Module 2: Coal petrography: Macro and micro lithotypes, Composition of macerals, application of coal petrography, Mineral matter in coal: Origin and chemical composition, Impact of mineral matter in coal process industry;

Module 3: Coal properties and their evaluation: proximate and ultimate analysis, calorific value, crossing and ignition point temperature, plastic properties (free swelling index, Caking index, Gray King Low Temperature Assay, Roga index, plastometry, dilatometry),

Module 4: physical properties like specific gravity, hard groove grindability index, heat of wetting, Crossing point temperature of coal, Behavior of coal at elevated temperatures and products of thermal decomposition, Classification of coal - International and Indian classification, grading of Indian coals;
Module 5: Coal Washing: Principles, objectives, coal preparation, washability characteristics; Selection, testing, storage and utilization of coking and non-coking coal. Use of coal by different industries.

Course Outcome:
CO1: To introduce processes of formation of coal, properties and evaluation
CO2: To understand coal preparation and washability characteristics of coal

Essential Reading:

Supplementary Reading:
5. S. P. Mathur, Mine Planning for Coal, M. G. Consultants, Bilaspur, 1993

REMOTE SENSING AND ITS APPLICATION
i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining Engg.
iii. Modules:
Module 1: Elements of photogrammetry, Stereoscopic Vision, Photo interpretation techniques, Definition and components of remote sensing, Electromagnetic waves and radiation principles, Multiconcept remote sensing,

Module 2: interaction of EMW with various ground components: vegetation, water, snow, soil and minerals;

Module 3: Sensors and platforms, False color composite, Digital image processing: geometric and radiometric correction, image enhancement, band ratio, edge detection, filtering, principal component analysis, and image classification, Normalized difference vegetation index,

Module 4: Application of remote sensing in hydrology, mineral exploration, natural hazards like landslide, flood, and earthquake, Identification of surface feature, drainage pattern, structural patterns.

Course Outcome:
CO1: Introduces the concepts of remote sensing and interaction of waves with various ground components
CO2: Study of Sensors and platforms including application of remote sensing in hydrology, mineral exploration

Essential Reading:

Supplementary Reading:

SOLID FUELS AND CLEAN COAL TECHNOLOGY
i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Mining Engg.

iii. Modules:
Module 1: Introduction: Processes of formation of coal, Theories of origin of coal, Eras of coal formation, Indian Coalfields and its subsidiaries: Occurrence and distribution, coal bearing formations, coal type and rank variation, Characteristics of major coalfields, Coal production from different sectors.


Module 3: Coal properties and their evaluation: proximate and ultimate analysis, calorific value, crossing and ignition point temperature, plastic properties (free swelling index, Caking index, Gray King Low Temperature Assay, Roga index, plastometry, dilatometry).

Module 4: Physical properties like specific gravity, hard groove grindability index, heat of wetting, Crossing point temperature of coal, Behavior of coal at elevated temperatures and products of thermal decomposition, Classification of coal - International and Indian classification, grading of Indian coals.

Module 5: Coal Washing: Principles, objectives, coal preparation, washability characteristics; Selection, testing, storage and utilization of coking and non-coking coal, Use of coal by different industries.

Course Outcome:
CO1: Comprehend the processes of coal formation and its occurrence.
CO2: Evaluate the essential properties of coal
CO3: Determine the washability potential of different types of coal and select the appropriate beneficiation process.

Essential Reading:

Supplementary Reading:
5. S. P. Mathur, Mine Planning for Coal, M. G. Consultants, Bilaspur, 1993

CLEAN COAL TECHNOLOGY

i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Mining Engg.

iii. Modules:

Module 2: Coal washing: Objectives and Techniques. Washability characteristics of coal
Module 3: Clean coal technology: Definition and Objectives, Technology Options; Pre-combustion, Combustion, Post Combustion and Conversion CCTs. Coal combustion options: FBC, IGCC, co-generation options.

Module 4: Carbon capture and storage, Storage Options for CO2: Types of geological storage projects. Screening reservoirs for suitability of CO2 storage

Module 5: Coal bed Methane Recovery and utilization, Coal Gasification (In-situ and surface Gasification), Coal to Liquid Technology.
Course Outcome:
CO1: Comprehend the processes of coal formation and its properties.
CO2: Determine the washability potential of different types of coal and select the appropriate beneficitation process.
CO3: Comprehend the concepts of clean coal technology.
CO4: Understand the application of CCTs by different industries.

Essential Reading:

Supplementary Reading:
2. N. Berkowitz, an Introduction to Coal Technology, Elsevier, 1993
5. S. P. Mathur, Mine Planning for Coal, M. G. Consultants, Bilaspur, 1993

MINE VENTILATION LABORATORY 2 credits [0-0-3]

Determination of Relative Humidity of Mine air with Fixed/stationary Hygrometers, and Whirling Hygrometers; Determination of Relative Humidity of air using Assman Psychrometer; Determination of cooling power of air using Kata Thermometer; Determination of CO % by MSA CO detector; Determination of percentage of CO and CO2 by Drager Multi Gas Detector (Model 21/31); Determination of Methane % by MSA D-6 Methanometer; Study of the construction and working of Flame Safety Lamp (VELOX GL-50, GL-60 and MSA type); Gas Testing by Flame Safety Lamp in a Gas Testing Chamber; Measurement of Air Velocity by (i) Vane Anemometer (ii) Electric Analog Velometer; Study of Pitot Static Tube & measuring of Air Velocity in a ventilation duct in combination with an Inclined Manometer; Measurement of dust concentration by (i) Gravimetric Dust Sampler, (II). Personal Dust Sampler; Measurement of dust concentration by High Volume Sampler; Measurement of Noise Level by Integrating Sound Level Meter (CEL-283)

ROCK MECHANICS LABORATORY 2 credits [0-0-3]

Preparation of Rock Specimens for various testing purposes; Study of Compressive Testing Machine; Determination of Protodyakonov Strength Index; Determination of Impact Strength Index; Determination of the Uni-axial Compressive Strength of rock materials; To Determine the Tensile Strength of a rock specimen by an Indirect Method (Brazilian Test); Determination of Point Load Strength Index; Determination of Shear Strength by Direct Shear Test; Determination of Modulus of Elasticity and Poission’s ratio of rock samples; Determination of Slake Durability Index of rock samples; Determination of Slake Durability Index of coal samples; Determination of Permeability of rock; Determination of C – φ by using Tri-axial Cell Unit; Determination of Index Parameter using Schmidt Hammer

COMPUTER APPLICATION IN MINING LABORATORY 2 credits [0-0-3]

Ore body modeling using SURPAC; Application of SURPAC for mine scheduling; Study of stress distribution around single opening using FLAC –2D; Study of stress distribution around single opening using FLAC –3D; Study of stress distribution around single opening using UDEC; Study of stress distribution around circular opening; Stress distribution around rectangular opening; Study of stress distribution around multiple openings; Study of deformation around circular opening; Study of deformation around single opening using FLAC –2D; Study of deformation around single opening using UDEC; Study of deformation around multiple openings
MINERAL PROCESSING TECHNOLOGY LABORATORY 2 credits [0-0-3]

Particle size analysis of different rocks and minerals; Study of Jaw Crusher and determination of its Actual Capacity; Finding out Reduction Ratio using jaw crusher; Verification of Rettinger’s Law using jaw crusher; Study of Hammer Mill and determination of its Actual Capacity; Finding out Reduction Ratio using Hammer Mill; Verification of Kick’s Law using Hammer Mill; Study of Rod Mill and determination of its Actual Capacity; Study of the effect of Ball Load and time on Grinding using Ball Mill; Study of Vibrating Screen and Determination of its Effectiveness; Study of Magnetic Separator and Determination of its Efficiency; Study of Baum Jig and Determination of its Efficiency.

GEOMECHANICS LABORATORY 2 credits [0-0-3]

Study of Universal Testing Machine; Evaluation of ground vibration using Blastmate; Determination of Explosive strength by V. O. D. Monitor; Determination of rock hardness by Hardness Tester; Determination of Rock In-situ Stress by Flat Jack Unit; Determination of the relation between the moisture content and the dry density of the loose rock materials using light compaction; Study of Bore hole stress meter; To study the Permeability characteristics of coal specimens; Determination of crushing strength of rock, slag, aggregate gravel by using LOS Abrasion Testing Machine; Determination of Aggregate impact value of rock/ concrete by using Aggregate Impact Test Apparatus; Determination of Impact Strength with Pendulum Impact Tester; Introduction to a few numerical modeling software’s etc.

MATERIAL HANDLING SYSTEMS LABORATORY 2 credits [0-0-3]

Study of bi-cable aerial rope-way; Study of headgear and pulleys; Study of cage & skip; Study of different types of keep; Study of scraper chain conveyor; Study of belt conveyor; Study of gate end box; Study of king detaching safety hook; Study of mechanism of shaft sinking; Study of winding shaft; Study of safety devices in haulage; Study of cage attachment to winding rope

MODEL PREPARATION LABORATORY 2 credits [0-0-3]

Preparation of surface mining models; Preparation of underground coal mining models; Preparation of underground metal mining models; Preparation of underground mine ventilation models; Preparation of underground transport models; Preparation of underground excavation models; Preparation of underground man riding models; Preparation of underground support models; Preparation of opencast bench models; Preparation of reclamation models; Preparation of models on blasting in opencast mines; Preparation of models on blasting in underground mines

SOLID FUEL TECHNOLOGY LABORATORY 2 credits [0-0-3]

Determination of Moisture Content of Coal; Determination of volatile matter content of coal sample; Determination of ash content of coal sample; Determination of the true and bulk density of supplied coal sample; Determination of caking index of coal; Determination of free swelling index of coal; Determination of washability characteristics of coal sample by float and sink analysis; Determination of calorific value of coal using bomb calorimeter; Determination of Hardgroove Grindability index of coal; Determination of Crossing point temperature of coal; Determination of Critical Air Blast value coal; assessment of spontaneous heating susceptibility of coal using DTA; Assessment of spontaneous heating susceptibility of coal using wet oxidation potential analysis.

MINE PLANNING
i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining Engg.
iii. Modules:
Module 1: Principles of Mine Planning: Mining industry in comparison to other industries, planning for mineral policy, Plans to be maintained in the mineral industry, Stages of planning of new mines, requirements of planning, Master Plan, Feasibility Report, Detailed project report;

Module 2: Technical considerations in Planning: Selection of method of mining, opening up of open cast mines and underground mines, development of open cast mines and underground mines, Division of mine lease area into mining units, location of entries, Surface layouts, pit bottom layout, Ventilation planning;

Module 3: Planning of mine workings and systems: infrastructure planning, production planning, Mineral handling plant, optimal planning, Planning of special methods of Coal and metal mines, Placer Mining, Sea bed Mining;

Module 4: Socio-Economic considerations: Social aspects, Environment Management Plan, estimation of mining costs and profits, restructuring planning,

Module 5: Issues and challenges of mine planning in the future, Mine Closure Plan; Computer applications in mine planning & design.

Course Outcome:
By the end of this course, students will be able to:
CO1: Prepare feasibility report for a mineral deposit
CO2: Generates valid orebody model and classification of deposit
CO3: Select mining method and extraction sequences of materials
CO4: Select suitable equipment according to the mining method

Essential Reading:
1. S. P. Mathur, Mine Planning for Coal, M. G. Consultants, Bilaspur, 1993

Supplementary Reading:
1. W. Hustrulid and M. Kuchta, Open Pit Mine Planning and Design, A. A. Balkema Rotterdam, 1995
3. PWJ Van Rensberg, Planning Open-pit mines, AA Balkema Cape Town, 1970

TUNNELING
i. Pre-requisites: Under graduate Physics and Mathematics
ii. Target Departments: Mining Engg.
iii. Modules:
Module 1: Design of tunnels: Rock mass classification, stability analysis of tunnels, elastic and plastic deformation;
Module 2: Ground control: stress conditions, behavior of ground, Geomechanics instrumentation,
Module 3: design of supports; Equipments, Tunnel Boring Machines, ventilation, tunnel economics.

Course Outcome:
CO1: To introduce rock mass classification and stability analysis of tunnels
CO2: To study various issues of geo-mechanics instrumentation and design of supports in underground constructions

Essential Reading:
Supplementary Reading:
1. R. V. Proctor, Rock Tunneling with Steel Supports
2. F. O. Franciss, Weak rock tunneling, Taylor and Francis, 1994
3. J. Johansen, Modern trends in tunneling and blast design, Taylor and Francis, 2000
4. F. D. Davidson, Tunneling and Transport, Elsevier APPLIED Science, 1987
5. Bieniawski Z. T, Rock Mechanics Design in Mining & Tunneling

ADVANCED SURFACE MINING
i. Prerequisites: Surface Mining
ii. Target Departments: Mining Engg.
iii. Modules:
   Module 1: Introduction, Indian context of advance surface mines, Advancement in mine unit operation. Planning of surface mines viz. Procedural steps of planning; Ore body description, Mining Systems, Ultimate pit configuration.

   Module 2: Design of surface mines, Feasibility Report & Detailed Project Report, Modern surface mining equipments;

   Module 3: Legislations related to surface mining, Mine Closure Planning.

Course Outcome:
CO1: To apply modern techniques of surface mining
CO2: To design surface mines using modern tools
CO3: To familiarize with legislation related to surface mining

Essential Reading:

Supplementary Reading:

MINING OF DEEP SEATED DEPOSITS
i. Prerequisites: Under graduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:
   Module 1: Exploration: Modern Exploration Techniques to Identify the Complex Coal Deposits; Classification: Classification of Coal Deposits Lying under Typical Geo-mining Conditions;

   Module 2: Challenges: Challenges to improve Production and Productivity from Deep Seated Deposits, Challenges in Liquidation of Locked-up Pillars;


   Module 4: Modern techniques: Application of Numerical Modeling Techniques to Control Ground Problems of Complex Deposits, Use of Modern Instruments for Strata Control of deep seated deposits,

   Module 5: In-situ Gasification and Mineral Biotechnology for Complex Coal Deposits.

Course Outcome:
CO1: Identify and understand the Complex Coal Deposits and challenges of exploitation
CO2: Analyze design requirement of experimental trials and apply Innovative Technologies in the field
Essential Reading:
1. R. D. Singh, Principles & Practices of Modern Coal Mining, New age international New Delhi, 1997
2. T. N. Singh, Underground winning of Coal, Oxford and IBH New Delhi, 1992

Supplementary Reading:
2. S. K. Das, Modern Coal Mining Technology, Lovely Prakashan, Dhanbad, 1992
4. S. P. Mathur, Coal Mining in India, M. S. Enterprises Bilaspur, 1999

ADVANCED COAL MINING
i. Pre-requisites: COAL MINING
ii. Target Departments: Mining Engg.
iii. Modules:
   Module 1: Extraction of thick seams: Problems and issues, recent experimental trials Chirimiri caving Method, Blasting Gallery Method, Integral Caving method, Sublevel caving method, Hydraulic Mining, Shield Mining;
   Module 2: Extraction underneath surface features: Non-Effective width (NEW), Back filling methods, Wide stall mining.
   Module 3: Extraction of multiple seams: Problems and issues, recent experimental trials, Parting failures and control, design of workings;
   Module 4: Extraction of locked up pillars: Status of Bord and pillar mining in India, techniques of extraction and future requirements;
   Module 5: Support systems: Strata behavior at greater depths, problems of strata control in high horizontal stress fields, design of support system.
Course Outcome:
CO1: to understand Problems in extraction of seams and design of workings
CO2: Analyze design requirement of support system to deal with typical coal mining conditions

Essential Reading:
1. R. D. Singh, Principles & Practices of Modern Coal Mining, New age international New Delhi, 1997
2. T. N. Singh, Underground winning of Coal, Oxford and IBH New Delhi, 1992

Supplementary Reading:
2. S. K. Das, Modern Coal Mining Technology, Lovely Prakashan, Dhanbad, 1992
3. S. P. Mathur, Coal Mining in India, M. S. Enterprises Bilaspur, 1999

ROCK MECHANIC APPLICATION TO ENVIRONMENTAL PROBLEMS
i. Pre-requisites: Under graduate Physics and Maths.
ii. Target Departments: Mining Engg.
iii. Modules:
   Module 1: Classification of Rock for specific engineering purposes - Underground, Surface, etc.
   Module 2: Mechanical properties of discontinues rocks – Planes of discontinuity in rocks, characteristics and orientation of Joints;
   Module 3: Measurement of rock mass deformability- Insitu Testing;
   Module 4: Applications - Opencast mining and slope stability, Underground mining and excavation, massive rocks, layered rocks, weak rocks;
   Module 5: Application to waste disposal and underground storage, application to earthquakes.
Course Outcome:
CO1: To highlight the importance of rock mass classification, and properties of joints etc
CO2: To study the application of rock mechanics to opencast and underground structures including waste disposal systems

Essential Reading:

Supplementary Reading:
1. L. Hartman et al., Mining Engineering Handbook, Society for Mining, Metallurgy and Exploration Inc., USA, 1992

ADVANCED METALLIFEROUS MINING
i. Pre-requisites: Metalliferrous mining
ii. Target Departments: Mining Engg.
iii. Modules:
   Module 1: Methods: Techno-economic analysis on choice of stoping methods,
   Module 2: high productivity methods: blast hole stoping, vertical retreat method of mining, block caving, raise stoping, underground bench blasting, stope design and production planning in the various methods of stopping;
   Module 3: Special underground excavations: shaft pockets, ore bins, ore transfer, ramp, decline, step mining methods,
   Module 4: stope fills: preparation, transportation and filling operation, stope design and production planning, methods of pillar extraction,
   Module 5: solution mining: in situ leaching, underground retorting, under-sea mining, introduction to novel mining methods, Special underground excavation and system of supports; Pillar extraction: methods of pillar extraction, salt, potash and sulphur mining- their special problems.

Course Outcome:
By the end of this course, students will be able to:
CO1: Understand the different metal mining method
CO2: Understand different factors associated with different stopping method
CO3: Understand the development, haulage system, blasting practices, extraction procedure, support design of different metal mining methods

Essential Reading:
1. Y. P. Chacharkar, A study of Metalliferous Mining Methods, Lovely Prakashan, Dhanbad, 1994

Supplementary Reading:
ROCK SLOPE TECHNOLOGY

i. Pre-requisites: Under graduate Physics and Chemistry

ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.

iii. Modules:


Module 2: Factors Affecting Slope Stability: Geological factors, slope geometry, ground water, equipment loading, dynamic loading and effect of time;


Module 4: stability analysis, numerical models, and empirical models; slope Mass Rating System, Slope instrumentation. Remedial measures;

Module 5: Design of Waste Dumps and Tailings Dams: stability analysis of opencast high walls and benches, overburden dumps, case studies.

Course Outcome:

CO1: to create awareness on mechanics of slope failures and various factors influencing slope stability in mines

CO2: To study slope stability analysis procedures including dump designs

Essential Reading:

Supplementary Reading:

MINE ENVIRONMENTAL ENGINEERING

i. Pre-requisites: Under graduate Physics and Chemistry

ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.

iii. Modules:

Module 1: Spontaneous Heating and Mine Fires: Spontaneous Heating: Causes, incubation period, detection, remedial measures.

Module 2: Mine Fires - Classification, causes, preventive measures, dealing with mine fires – direct and indirect methods, reopening of scaled off areas;

Module 3: Explosion: Fire-damp Explosion - Limits of inflammability of methane, causes of ignition, nature of fire damp explosion, propagation and prevention. Coal-dust Explosion -
Index of inflammability, factors affecting explosibility of coal dust, causes and safeguards. Propagation of coal dust explosions, Investigation after an explosion

Module 4: Mine Illumination: Its effects on safety, efficiency and health, Flame and electric safety lamps- their uses and lamp-room – lay out and organization, standards of illumination in mines, lighting from the mains, photometric illumination survey, Miners’ diseases

Course Outcome:
CO1: To introduce various issues of spontaneous heating and mine fires including classification of mine fires
CO2: To study various issues of explosion in mines and illumination requirements

Essential Reading:

Supplementary Reading:

ENVIRONMENTAL IMPACT ASSESSMENT

i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:


Module 5: CASE STUDIES: Case studies related to the following sectors - Infrastructure - Mining – Industrial - Thermal Power - River valley and Hydroelectric - Nuclear Power

Course Outcome:
CO1: To understand various components and methods, prediction, assessment of environmental impacts due to mining
CO2: To study the procedure for preparation of Environmental Management Plan

Essential Reading:

Supplementary Reading:

ECO-FRIENDLY MINING

i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Mining Engg.
iii. Modules:
Module 1: Overview: Basic concept of eco-friendly mining. Selection of eco-friendly equipment and exploitation operations, Environmental Parameters:
Module 2: Water quality – physical, chemical, biological, criteria and standards. Classification and chemistry of major air pollutants, Soil chemistry – nature and importance of soil, soil properties, soil amendments,
Module 3: Waste Management: Waste water management – sources characteristics, techniques of treatment. Acid mine drainage – occurrence, effects and treatment techniques; Solid waste management for mine spoils,

Course Outcome:
CO1: Understand the basic concepts of eco-friendly mining and its application.
CO2: Select and adopt appropriate technologies for better environmental conditions in mines.
CO3: Comprehend the role of EIA/EMP process in eco-friendly mining practices.
CO4: Estimate the extent of environmental impact due to mining and decide the management options.
CO5: Understand the process of rehabilitation and mine closure and its implementation.

Essential Reading:

Supplementary Reading:

ENVIRONMENTAL POLLUTION AND CONTROL IN MINES

i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.

iii. Modules:

Module 1: General: Environmental issues in Mineral Industry- National and Global, Environmental impacts of Mineral exploitation - in underground and opencast mining.; Land Environment: Subsidence, visual impacts, landscape pollution, land degradation, land reclamation, land use, landscape planning, ecology.;

Module 2: Societal Development: Socio-economic impacts, sustainable development, concept of carrying capacity based planning; Pollution: Water - Availability, quality, pollution and treatment, Liquid effluents: Quality, treatment and disposal.

Module 3: Solid Wastes - Generation, treatment and disposal, hazardous waste management and planning. Tailings disposal & treatment systems

Module 4: Air: Pollution, monitoring and Control. Noise and Ground vibration - Causes, precautions, prevention and reduction; Environmental Management Plan (EMP), Environmental Impact Statement (Environmental Impact Assessment (EIA)),

Module 5: Environmental Legislation in India. Environmental Audit of Mining EIS) projects

Course Outcome:
CO1: To create awareness on various environmental issues in Mineral Industry, societal development etc
CO2: To familiarize with the treatment and disposal of solid Wastes, air pollution and Environmental Legislation in India

Essential Reading:

Supplementary Reading:

SOLID WASTE MANAGEMENT

i. Pre-requisites: Under graduate Physics and Chemistry

ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.

iii. Modules:

Module 1: Classification & characterization of waste, collection,

Module 2: Handling of Industrial (Mining, Thermal, Chemical, Radioactive, Biomedical, etc.) and Domestic Waste,

Module 3: Utilization of wastes, Federal and State regulations on Waste Management, Recycling, Recovery and Reuse of Wastes,


Course Outcome:
CO1: To introduce characterization and Handling of Industrial and Domestic Waste waste
CO2: To study various approaches for Utilization of wastes, and Optimization of waste Disposal System

Essential Reading:


Supplementary Reading:

1. Hazarding waste Rules, 1989

MINE LEGISLATION AND SAFETY ENGINEERING

i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:

Module1: Mine Legislation: General principles of Mining Law, Principal Provisions of Mines Act, Mines and Minerals (Regulation and Development) Act,

Module 2: Mineral Concession Rules, Mines Rules 1955, Electricity Rules, Industrial Disputes Act, 1947, Mine Rescue Rules; Mine Safety:

Module 3: Accidents- Their causes and prevention, accident statistics, rates of accidents, relation between accidents and efficiency, accident reports, cost of accidents.;

Module 4: Safety risk assessment and management, Safety Audit, Occupational health and safety in mines. Mine safety management systems, Safety education and training

Course Outcome:
CO1: To introduce General principles of Mining Law including various acts, rules, regulations and byelaws.
CO2: To learn procedures for preparation of accident reports, Safety risk assessment and management

Essential Reading:


Supplementary Reading:


MINE FIRES AND SPONTANEOUS HEATING

i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.

iii. Modules:

Module 1: Mine Fires: Accidental Fires – it causes and precautions, Survey of various causes of mine fires with statistical data of Indian mines. Physical and chemical factors governing proneness to fire in coal and metaliferrous mines

Module 2: Various methods adopted to combat fires and their advantages and disadvantages. Advances in fire fighting techniques and equipments, rescue operations in fire-zones.

Module 3: Spontaneous Heating: Various causes of spontaneous heating and statistical data in Indian mines, Theories of spontaneous heating of coal, Geological, Mining and Seam factors governing spontaneous heating. Intrinsic and extrinsic properties of various substances e.g. porosity, permeability, pore distribution, moisture etc. on spontaneous heating

Module 4: Different experimental techniques including modern techniques like DTA/TGA and DSC to measure liability indices and relative proneness of spontaneous heating; use of clean coal technology and neural network to detect spontaneous tendency, effect of microwave treatment and pyrite removal on spontaneous heating; Sampling of mine atmosphere, Interpretation of mine air analyzing data, fire risk management, environmental indices, Different methods to seal off fire areas

Module 5: Reopening of sealed off fire areas; Early detection of spontaneous heating in mines and stacks, recent trends to eliminate recurrence of spontaneous heating.

Course Outcome:
CO1: To understand the causes of fire/spontaneous heating and precautions in coal and metaliferrous mines
CO 2: To introduce experimental techniques including modern techniques like DTA/TGA and DSC to measure liability indices and relative proneness of spontaneous heating
CO3: Analyze the data, fire risk management, environmental indices and different methods to seal off fire areas

Essential Reading:

Supplementary Reading:

MINE MANAGEMENT
i. Pre-requisites: Under graduate Physics and Chemistry

ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.

iii. Modules:

Module 1: Introduction: Evolution of management; theory and practice; principles of scientific management; elements of management function; planning; organization and control; structure and design of organization for mining enterprises.

Module 2: Personal Management: Selection; training and development of human resources for mining enterprises; leadership; study of traditional leader behavior; autocratic; democratic and Laissez-Faire behaviors; Production Management: Determination of norms and standards of operations by work study; analysis of mine capacities and capability; production planning; scheduling and control; short term and long term planning; productivity; concepts and measurements; application of Ergonomics in mine operation.
Module 3: Financial Management: Capital budgeting; techniques for mining project; project evaluation; payback period and IRR; methods of cost analysis and cost control; breakeven charts; working capital management.

Module 4: Materials Management: ABC Analysis, Inventory Management; Purchase policies, P and Q system, inventory control, Review period, lead time. Behavioral Sciences for Management: Conflict management; conflict in organization; sources of conflict; dealing with conflict; organizing for conflict resolution; conflict and growth; Individual motivation; two way personal communication.

Module 5: Maintenance Management: Definition, Classifying Reliability, Types of Maintenance; Break-down, scheduled, preventive, predictive, protective and lean maintenance. Marketing Management: Strategic planning & marketing management processes, marketing environment, marketing information systems, market management and forecasting; New product development processes.

Course Outcome:
CO1: To introduce theory and practice, principles of scientific management.
CO2: To study various issues of Personal, Financial, Maintenance and Materials Management.

Essential Reading:
3. SC Saksena, Business Administration and Management, Sahitya Bhawan, Agra.

Supplementary Reading:
2. M. Telsang, Industrial Engineering and Production Management, S. Chand & Co. Ltd., New Delhi

MINE ENVIRONMENTAL ENGINEERING LABORATORY     2 credits   [0-0-3]

Study of MSA type Gas mask (Model: “SW”, Air purifying filter), (i) Filter type apparatus and (ii) Self Rescuer; Assessing spontaneous heating susceptibility of coal using DTA / wet oxidation apparatus; Study of Self Contained Breathing Apparatus. (i) Drager BG-174, (ii) By Travox-120; Study of Drager Pulmotor (Model: PT-60); Estimation of SPM concentration in air using high volume samplers; Study the construction and working of Explosion Proof Fire Stoppings; Determination of susceptibility of coal by chemical method or by puff temperature method; Determination of water quality parameters using water analyzer kit; Determination of flammability temperature of coal by using inflammability index apparatus; Determination of nutrient status in soil using soil test kit; Measurement of Noise Level by Integrated Sound Level Meter (Model: CEL-283EX) and B & K sound level meter; Measurement of Lux by Light Meter.

MINE PLANNING AND DESIGN LABORATORY     2 credits   [0-0-3]

Preparation of data base for mine evaluation; Create a geological data base and import all data files; Performing data compositing and statistical analysis; Create digital terrain model and surface contouring; Create section and digitization of individual sections; Create solid model using sections; Perform volume and area calculation of solid model, Union and intersection of different sections; Create block model; estimation of block models using inverse distance and polygonal method; Performing variogram analysis, fitting variogram, checking anisotropy; Intersection of block model and solid model; resource evaluation using ordinary kriging technique; Blast design using SURPAC software; Mine design using SURPAC software; Ultimate pit limit calculation; Determination of Grade tonnage curve and study the conditional based in estimation.

SIMULATION AND MODELING OF MINING SYSTEMS LABORATORY     2 credits   [0-0-3]
Simulation of underground openings-2D continuum models; Simulation of underground openings-3D continuum models; Simulation of underground openings- discontinuum models;
Study of stability of underground opening – Mohr-Coulomb model; Study of stability of underground opening – Hoek-Brown model;
Simulation of opencast workings; Study of stability of slopes – 2D continuum models; Study of stability of slopes – 3D continuum models; Study of stability of slopes – 2D discontinuum models;
Design of supports for underground openings; Simulation of thick seam workings; Simulation of multiple seam working.

Geographic Information system (GIS)  3 credits  [3-0-0]
COURSE OBJECTIVES: An engineer has to be highly proficient in dealing with different maps which they may encounter during their professional career. With the advent of information technology, computer-aided systems are being widely used to handle the geographic datas. Hence, it is essential for the students to get well acquainted with this evolving geographic information system. This course will help the students from mining, civil, planning and computer science engineering to understand the principles and working of a Geographic Information System.
COURSE CONTENT: Introduction to GIS, datums and map projections, Basic GIS data-structures and topology, Spatial database management, digital terrain mapping, spatial analysis and geostatistics, Introduction to various GIS packages, GIS model building, overview of application of GIS in mining and other related industry through interesting case-studies.
TARGET DEPARTMENTS: Mining Engineering, Civil Engineering, Computer Science & Engineering, Planning & Architecture
COURSE OUTCOME:
CO-1: The students will have a strong concept about the principles and working of a Geographic Information System
CO-2: The students will gain practical experience of working on a GIS package.
CO-3: The students will be able to create, manipulate and analyse spatial datas in GIS to suit their requirement.
COURSE MODULES:
Module 1: Introduction to GIS, History of GIS, Basic concepts, definitions and terminologies, Overview of GIS application in various real world scenarios
Module 2: Datums and Map Projections, Basic Principles, Types of Projections, Azimuthal, Cylindrical, Conic, Mathematical
Module 3: GIS data-structures and topology, Raster data-structures, Vector data-structures, Topology
Module 4: Spatial database management, Introduction to spatial database, Attribute type and tables, Querying with spatial conditions
Module 5: Spatial analysis and geostatistics, Spatial analysis operations in Raster, Spatial analysis operations in Vector, Interpolation, Digital terrain mapping
Module 6: Working with GIS packages, Introduction to various GIS packages, GIS model building
Module 7: Overview of GIS application in mining and other related industry through interesting case-studies

Apart from the above, an appropriate number of classes will be dedicated for demonstration on working with a GIS package.

ESSENTIAL READING:
SUPPLEMENTARY READING:


LONGWALL MINING TECHNOLOGY 3 credits [3-0-0]

i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:
   Module 1: Longwall Mining Trends, Equipment used for long wall mining, Indian scenario, international scenario, single-entry longwall mining technology
   Module 2: Longwall Pillar Design, Barrier pillars, Design of Chain pillars,
   Module 3: Longwall Strata Mechanics, Horizontal Stress, Monitoring of strata behavior, Condition monitoring of equipment
   Module 4: Shield Design, Secondary Support Design, Shearer Design, Armored Face Conveyor Design,
   Module 5: Longwall Ventilation – Dust and Methane Control, Subsidence

Course Outcome:
CO1: Identify and understand the factors influencing performance of long wall mining
CO2: Analyze design requirement of barrier pillars, support system for gate roads and long wall face
CO3: Apply different instruments for evaluation of strata and support condition

Essential Reading:


Supplementary Reading:


GROUND CONTROL INSTRUMENTATION LAB 2 credits [0-0-3]

List of experiments to be conducted
1. Study of instruments for monitoring convergence in mines.
2. Study of instruments for monitoring stress in underground workings.
3. Study of instruments for monitoring load on supports.
4. Study of instrumentation for monitoring ground behavior around Longwall workings.
5. Study of instruments for slope monitoring in opencast mines.
7. Study of instruments for monitoring bed separation in mines
8. Study of instruments for monitoring ground vibrations due to blasting.
9. Study of instruments for strata behavior monitoring in thick seams.
10. Study of instrumentation for monitoring ground behavior in metal mines
UNDERGROUND COAL MINING LAB 2 credits  [0-0-3]

List of experiments to be conducted

1. Study of layouts of Board and Pillar development working by without panel system.
2. Study of layouts of Board and Pillar development working by panel system.
3. Study of layout of Longwall Advancing system.
4. Study of layout of Longwall Retreating system.
5. Study of various line of extraction used for pillar extraction.
6. Study of stock extraction method under difficult roof conditions.
7. Study of surface arrangement required for stowing.
10. Study of layout of Double Unit Longwall Faces.

MINE SUBSIDENCE ENGINEERING

i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:
Module 1: Causes – Effect of depth, width of excavation, seam thickness and angle of draw.
Module 2: Types of subsidence – non-effective width, sub-critical, super-critical width.
Module 3: Theories of subsidence, sub-surface subsidence due to mining. Rock kinematics, Extent of movement in the overlying beds.
Module 4: Special Methods of Mining to control subsidence. Monitoring of subsidence, Prediction and nomograms of subsidence.
Course Outcome:
CO1: Identify and understand the factors influencing surface subsidence due to underground mining
CO2: Analyze design requirement of underground workings for control of subsidence
CO3: Apply different instruments for evaluation of subsidence

Essential Reading:

1. Mining Subsidence Engineering by Dr. Helmut Kratzsch ISBN: 978-3-642-81925-4 (Print) 978-3-642-81923-0 (Online) Publisher Springer Berlin Heidelberg

Supplementary Reading:


BLASTING TECHNOLOGY 3 credits  [3-0-0]

i. Pre-requisites: Undergraduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:
Module 1: Commercial Explosive: Classification, Low and High Explosive, Permitted and non-permitted explosives, Important Characteristics, ANFO, Slurry, Emulsion explosives, Primers and boosters, cast booster, Bulk explosive system.
Module 2: Initiation Systems: Storage and Transportation Of Explosives Detonators, safety fuse, Detonation cord, Detonating relay, Non-electric initiation system, NONEL, Electronic detonators, Exploder and other blasting tools, Magazines, transportation Of explosives.


Module 4: Underground Blast Design: Terminology, cut holes, easers, trimmers, commonly used cut patterns, Wedge cut, drag cut, Pyramid cut, Burn cut, etc., blasting in sinking shaft, underground coal mine blasting, Series and parallel connections of detonators.

Module 5: Environmental Impact of Blasting: Blast induced ground vibration, its measurement, prediction and control, Noise, its Measurements and control, Fly rock its causes and control, Controlled Blasting Techniques.

Course Outcome:
CO1: Identify and understand the factors influencing performance of blasting
CO2: Analyze design requirement of blasting in opencast and underground mines
CO3: Apply different instruments for evaluation of ground vibrations due to blasting

Essential Reading:
1. Surface Blast Design by C.J. Konya.

Supplementary Reading:
1. Indian Explosive Act and Rules.
2. Explosives and Blasting by G.K. Pradhan
3. Engineering Rock blasting operations, Bhandari
5. Surface Blasting, P. Pal Roy

BLASTING TECHNOLOGY Lab 2 credits [0-0-3]

List of Experiments:
1. Measurement of ground vibration by seismograph
2. Development of predictor equation from the recorded data
3. Measurement of VOD by VOD mate and its analysis
4. Study of various fragmentation assessment techniques
5. Handling of WIPFRAG software
6. Design of blast for coal face
7. Design of blast for underground metal mine
8. Design of blast for bench blasting
9. Study of various blasting tools
10. Study of bulk explosive systems

COAL BED METHANE 3 credits [3-0-0]
i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:
Module1: Calcification process and coal grades. Methane generation and storage in coal; Geological control in Coal Bed Methane (CBM) exploration;
Module 2: Methane adsorption, desorption in coal. Coal as CBM reservoir: In-place methane estimation; Transport of methane in coal-bed. Drilling & Completion of a CBM hole/well.

Course Outcome:
CO1: Identify and understand the factors influencing performance of coal bed methane
CO2: Analyze design requirement of methane estimation, gas-water separation, transport etc

Essential Reading:

Supplementary Reading:

UNDERGROUND SPACE TECHNOLOGY 3 credits [3-0-0]
i. Pre-requisites: Under graduate Physics and Chemistry
ii. Target Departments: Ceramics Engineering, Chemical Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Communication Engineering, Civil Engg., BM, BT, MA, LS, Chemistry and Physics, etc.
iii. Modules:

Module 1: Introduction: Natural caves, archeological caves and their construction; Tunnels for various purposes like road, rail, and hydropower tunnels. Need for underground space: Congestion in cities and its impact on development of social infrastructure for transport, water and power supply, separation of pedestrian and motorized vehicles and its movements, storage of materials, defense facilities including civil shelters.

Module 2: Engineering utilities: Hydropower tunnels and caverns; Underground storage for LPG and crude oil. Geo-engineering investigations: Topographic and geological survey, auguring, drilling, soil and rock sampling, and testing; Preparing sub-surface geological cross section; Geo-radar use and data analysis for shallow tunnels; Geophysical investigations to prove deeper sub-surface features; Physico-mechanical properties and collection of rock mechanical data.

Module 3: Planning and design: Assessment of behavior of tunneling media, deformation modulus and rock pressure assessment; determination of appropriate size and shape; Design of openings in rocks with the help of field data; Instrumentation and monitoring; Numerical modeling to assess the stability.

Module 4: Support design and stabilization techniques for underground tunnels and caverns: Steel supports, rock bolts, shotcrete, wire mesh, chain link fabric and fibre reinforced shotcrete and other ground Consolidation/grouting techniques.

Module 5: Other storage: Grain storage, their advantages, disadvantages, underground cold storage and cellar for foods and beverages. Nuclear waste disposal: Conditions for waste disposal, effect of radioactivity and heat on surrounding

Course Outcome:
CO1: Identify and understand the need for underground space
CO2: Analyze design requirement of openings in rocks
CO3: Apply different instruments for evaluation of strata and support of different types-resin bolts, shotcrete etc

Essential Reading:

Supplementary Reading:

NOVEL AND INNOVATIVE MINING PRACTICES 3 credits [3-0-0]

i. Course modules:
Module 1: Innovative Mining Technology: Opencast and Underground

Module 2: Automation, Robotics, Tele-monitoring in Mines, Virtual Reality and Animation

Module 3: Extra-Terrestrial Mining: Deep Sea Mining, Moon Mining, Asteroid Mining, Mining in the Arctic and Antarctica

Module 4: Underground Gasification and Coal Bed Methane, Remote Sensing, GIS & GPS Applications

Module 5: Innovations in Instrumentation and Communication System, Bioleaching and Heap Leaching, Clean Coal Technology

ii. Course Outcomes
CO1: To understand novel mining methods
CO2: To study innovative mining practices

Essential Reading

Supplementary Reading:

Mine Hazards and Rescue

Mine gases: properties, physiological effects, occurrence, detection, and monitoring; Degassification of coal seams; Sampling and analysis of mine atmosphere; Mine fires; Explosions from firedamp and coal dust; Rescue and recovery; Inundation of mines and dewatering; Mine illumination

SURFACE MINING ENVIRONMENTAL ENGINEERING

Modules:
Module 1: Overview: Basic concept of environmental engineering. Environmental issues in surface mining activities.
Module 2: Air Pollution - sources, characterization, ill effects of air pollution. Standards, measurement, monitoring, and control measures of various air pollutants.
Module 4: Noise Pollution - Basics of acoustics, sound power, intensity and pressure levels. Sources, characteristics and ill effects of noise pollution in the mining industry. Measurement of noise level and its management.
Module 5: Waste Management: types of waste, sources, and management.

ii. Course Outcome:
CO1: Understand the environmental problems and issues in surface mining.
CO2: Learn the method for monitoring and assessing the various environmental problems.
CO3: Learn the management and control of various environmental problems faced during the surface mining.

Essential Reading:

BULK MATERIAL HANDLING
i. Pre-requisites: Undergraduate Mining machinery, Applied Mechanics and Mine development

ii. Target Department: Mining Engineering

iii. Modules:

Module 1: Mine hoist: Drum and koepe winders, constructional features, kinematics, torque and power calculation, speed control, safety contrivances, selection of mine winders, cages, skip, suspension gears, headgear structures, cage guides, pit top and pit bottom circuits and layouts;

Module 2: Conveyors: Belt conveyor, chain conveyor, cable belt conveyor, shaker conveyor, vibratory conveyor, constructional features and power calculations, selection and application;

Module 3: Aerial Ropeway: Mono-cable, bi-cable, twin-cable ropeway, constructional features and power calculations, selection and application;

Module 4: Scraper Haulage: Constructional features, applicability, advantages and disadvantages;

Module 5: Men and material transportation: Cutting and loading machines for coal/ore, special men and materials transport in mines, men riding systems in mines.

Course Outcome:

CO1: Design and application of hoisting system

CO2: Application of men and material transport system

CO3: To enhance the knowledge and design concept of scraper haulage, aerial ropeway and conveyor system in mines.

Essential Reading:


Supplementary Reading:


Drilling and Blasting

Exploratory drilling and production drilling; Drillbility of rocks; Classification and properties of explosives; Detonators, detonating cords, and nonel detonators; Blasting practices in underground and surface mines; Blast Design; Handling of Explosives; Transport of explosives, storage and handling

Rock Fragmentation

Mine System Engineering and Optimisation

Pre-requisites: Undergraduate Mathematics and Statistics

v. Target Departments: Mining Engineering

vi. Modules:


Module 2: Theory and computation of linear and integer programming, Limitations of LPP, Sensitivity analysis, dynamic programming, applications of linear programming on mine system optimization.

Module 3: Transportation and assignment problems: Introduction, formulation of model and analysis.


Module 6: Reliability analysis: Definition, causes and types of failures, reliability expressions for constant, increasing, and decreasing hazard rates, data analysis, probability plots for various distributions. Reliability analysis for series, parallel, series-parallel system.

Module 7: Inventory management: Importance & scope of inventory control, types of inventory, costs associated with inventory, inventory control, selective inventory control, economic order quantity, safety stocks, inventory management systems.

Module 8: Simulation Modeling: Types of simulation, Monte Carlo simulation technique.

viii. Course Outcome:

By the end of this course, students will be able to:

CO1: Develop necessary analytical skills, methods and ways of thinking to tackle and analyze complex mine organizational problems for better decisions making.

CO2: Formulate the real life system optimization problems into mathematical models

CO2: Solve the mathematical models using operation research techniques

CO3: Incorporate the uncertainty of the mining systems parameters in optimization model

Essential Reading:

2. "Operations Research: Principles and Practice" by Ravindran, Phillips and Solberg, Wiley India
3. "Reliability Theory with Application to Preventive Maintenance (PM)" by Ilya Gertsbakh, Springer.

ROCK EXCAVATION ENGINEERING 4 credits [3-1-0]

Ground Characterization: Character of Rock Materials and Rock Mass, Stresses, Site Investigation; Measurement, prediction and monitoring behavior, Fragmentation Blasting, Drilling, Breaking and Cutting, Rock Reinforcement. Blast free excavation,

Essential Reading:


Supplementary Reading:

3. L. Hartman, Mining Engineering Handbook, Society for Mining, Metallurgy and Exploration Inc., USA, 1992

**Project MANAGEMENT** 4 credits [3-1-0]
Management and its functions, Evolution of scientific management and management sciences. The production systems, Elements of its design and operation, Design of physical facilities; Plant location and layout, production development and analysis, production system including sales. Technology Forecasting, Planning inventory models, Design of job and wage system, Methods study, work measurement, Job evaluation; Wage and incentive plans, Budgetary Control, Cost analysis, Depreciation, Productivity: Concepts and measurements, Organizational structure for management functions, Project Planning, Evaluation and Management; Operation Research Applications in Management, MIS, Environmental Management and Safety Management Systems, Principles of financial management, Statistical Quality Control, Simulation and Modeling Applications in Management.

Essential Reading:

Supplementary Reading:
1. O.P. Khanna, Industrial Engineering and Management, Dhanpat Rai Delhi, 1993

**ENVIRONMENTAL Control and management** 4 credits [3-1-0]
The theory and practice of creating safe, healthy and efficient working environment at an underground or surface mine. Surface mining vs. ecological balance; Air pollution from surface mining and processing – monitoring, control and standards. Air pollution dispersion; models. Water pollution – types, control and monitoring, ground water contamination. Noise and ground vibrations; Tailings dams design, Reclamation, Revegetation, Environmental legislation, Environmental management plan and Economics of mining environment control; Environment & development planning systems & methodologies based on the principle of sustainable development including: environmental impact assessment & project assessment; site assessment & site planning; local & regional planning systems for urban & regional environmental planning, conservation planning.

Essential Reading:

Supplementary Reading:

**HAZARDOUS WASTE MANAGEMENT** 3 credits [3-0-0]
INTRODUCTION: Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, plastics and fly ash;


Essential Reading:

Supplementary Reading:

NOISE IMPACT ASSESSMENT AND CONTROL 4 credits [3-1-0]

Fundamentals of Noise, Sources and Classification of Noise; Mechanism of Hearing : Types of Hearing Loss, AAOO Criteria; Noise Measuring Instruments and Survey: Sound level meter, audiometer, dose meter, octave band analyzer; Noise Indices : Leq, Ldn , TNI, NII ; Noise Control Measures: noise control at source, path and receiver, acoustic barriers, enclosures, control of machinery noise, community and industrial noise control strategies; Noise Standards in India and Abroad; Noise Impact Assessment and Prediction Techniques ; Noise Modeling Software : ENM, CONCAWE, OCMA, VDI

Essential Reading:

Supplementary Reading:

Advance Rock Mechanics

Underground Metal Mining Method

Resource Evaluation and Geostatistics

Land Reclamation and Eco-Restoration

Safety Risk Assessment and Management

Mining System Laboratory
Hazard and Rescue Laboratory

DEPARTMENT OF PLANNING & ARCHITECTURE ENGINEERING

Course outcomes for core courses:

a. The broad education necessary to understand architecture in a global context – techno-economic, environmental, socio-cultural, and political
b. A recognition of the need for, and an ability to engage in, life-long learning
c. An ability to design and conduct inquiries, and to analyze and interpret data
d. An ability to identify and formulate programmatic requirements
e. An ability to design a system, component, or process to meet desired needs such as aesthetic, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
f. An ability to use techniques, skills, and technology for architectural practice
g. An ability to apply knowledge of architecture
h. An ability to communicate effectively
i. An ability to function on multidisciplinary teams
j. An understanding of professional and ethical responsibilities

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<th>Course Title</th>
<th>Course Outcome</th>
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<td>Visual Arts Laboratory I</td>
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<td>3</td>
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<td>Basic Design laboratory</td>
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<td>Non-graphic Computer Application</td>
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1. First semester

**PA1201 Architectural Graphics-I**

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<th>Objective</th>
<th>To understand and execute different engineering diagrams using hand</th>
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<tr>
<th>Module I</th>
<th>Introduction to IS code of engineering drawing (dimensioning, labeling, sheet formatting); concept of scale.</th>
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<tr>
<td>Module II</td>
<td>Curves and conic sections (ogee curves, parabola, ellipse, hyperbola, cycloid, trochoid, involutes).</td>
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<tr>
<td>Module III</td>
<td>Projection of points, lines (traces and true lengths). Projection of planes and auxiliary planes.</td>
</tr>
<tr>
<td>Module IV</td>
<td>Projection of solids (cube, prism, pyramid, cylinder, sphere, cones).</td>
</tr>
</tbody>
</table>

**Essential readings**


**Supplementary readings**


**PA 1401** Visual Arts Laboratory I

<table>
<thead>
<tr>
<th>Objective</th>
<th>To understand the systematic and technical processes of creating works of art, and to execute the processes manually</th>
</tr>
</thead>
</table>

Credits: 2
Module I  **Drawing with pencil – Basics of pencil sketching.**
Assignments: 1. Hatching, 2. Still life sketching of any object from different angles, and 3. Outdoor sketching

Module II  **Rendering with pen and ink – Basics of pen and ink rendering, and Graphical representation of architectural elements**
Assignments: 1. Conversion of the pencil sketched still life into pen and ink rendering, 2. Pen and ink rendering of given images of buildings, 3. Landscape design of an urban park, delineation of design elements in plan, elevation, and section

Module III  **Colouring (poster colour) –** Introduction to colour theory: colour wheel, additive- subtractive, colour pallets (complementary, analogous, triad etc.)
Assignment: 1. Pattern (2D composition of shapes) using different colour

Module IV  **Composition –** Basics of composition: proportion and balance of design elements through their sizes, positions, typography, colour pallets etc.
Assignment: 1. Poster design, 2. Book cover design

**Essential Readings**

**Supplementary Readings**

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**PA1403 Basic Design laboratory**  
**Credits: 2**

**Objective**  
To design different configurations of space using simple geometrical elements; volumetric analyses of spaces and their aesthetics  
To develop technical skills such as simple drawing, painting and cutting needed to deliver well composed designs.

**Module I  2-dimensional compositions**
Introduction to design principles; study of lines, shapes, value, colour (colour theory), texture; appreciation of contrast, harmony, balance, emphasis, rhythm, scale and proportion; understanding of aesthetics of basic 2-dimensional shapes; creating compositions using various media/material,

**Module II  3-dimensional compositions**
Study of elementary forms, envelopes; principles of 3-dimentional design; exploration of relationship between form and space, understanding aesthetics with 3-dimensional forms, appraisal of spatial, volumetric implications due to transformation of forms and spaces, application of unit Module I on 3-

**Module III  Pragmatic design**
Understanding the properties of material and creating a 3-dimentional composition, through trial and error method, that best showcases the property

**Module IV  Techniques of graphic expression to represent design ideas**

**Essential readings**  

**Supplementary readings**
As suggested by the studio in-charge

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**PA1901 Non-graphic Computer Application**  
**Credits: 2**
### PA1405  
**Principles of Architectural Design**  
**Credits:** 2

**Objective**
To understand the visual significance of basic elements of design

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I</td>
<td>Primary element- point, line, plane, volume; form- form and shape, primary shape, regular forms, transformation of forms, articulation of forms, surface articulation; form and space- unity of opposites, horizontal elements defining spaces, vertical elements defining spaces, quality of architectural spaces, degree of enclosure; organization- organization of form and space, spatial, centralized, radial, linear,</td>
</tr>
<tr>
<td>Module II</td>
<td>Circulation- approach, entrance, path, path-space relationship; proportion and scale- material proportion, structural proportion, manufactured proportion, proportioning system, golden section, regulating lines, classical orders, renaissance theories, modular, ken, anthropometry, scale, visual scale, human</td>
</tr>
<tr>
<td>Module III</td>
<td>Principles- ordering principles, axis, symmetry, hierarchy, datum, rhythm, repetition, transformation</td>
</tr>
<tr>
<td>Module IV</td>
<td>Visit to nearby buildings to understand the significance of various design elements in defining aesthetical character of the building</td>
</tr>
</tbody>
</table>

**Essential readings**
- Bucki, Lisa A., Walkenbach, J.,Wempen, F.,Alexander M., Kusleika, |

**Supplementary readings** None

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### PA 1501  
**Evolution of Architecture I**  
**Credits:** 2

**Objective**
To understand the evolution of architecture in western world, starting from Sumerian architecture up to the neoclassicism, through the context, intentions, strategies, and relevance of different architectural movements.

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### Essential readings

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### Supplementary readings
None
Module I: Mesopotamian architecture and its context (social, religious, economic and geographic background), building materials used, building types (temples, forts) and town planning (Babylonia); Egyptian architecture and its context, major building types – temples (cult and mortuary), tombs (mastabas and pyramids), influences of natural elements in built form.

Module II: Greek architecture and its context, major building types, geometry; Roman architecture and its context, major building, innovation in building materials and structural systems and their usage.

Module III: Byzantine architecture and its context, major building types, innovation in structural system, and space planning.


Module V: Gothic architecture and its context – the evolution of architectural forms, structural systems, and their influences; Examples, and their analyses.

Module VI: Renaissance architecture, and its context; phases of Renaissance architecture, and its context; mannerism; Examples, and their analyses.

Module VII: Baroque and Rococo architecture and its interpretations across Europe and their colonies; Examples, and their analyses.

Module VIII: Introduction to Neoclassicism; Students’ Seminar on the neoclassical architecture in

**Essential Readings**

**Supplementary Readings**

**PA 1701: Building Materials – I**

**Objective**
To study the properties of basic building material used in the built environment.

**Module I**
- Stones: classification of stones; common building stones used in India; characteristics and use of stones; dressing of stone; artificial stones; introduction to stonework: rubble and ashlar masonry.

**Module II**
- Timber – classification; qualities of timber for construction; defects, seasoning, storage and preservation of timber; use of different types wood in various parts of building; industrial timber: veneers, plywood, fibreboard, etc.

**Module III**
- Brick - composition, sizes, properties and classification of bricks, tests for bricks; introduction of brickworks: masonry bonding & ornamental bonding, substitutes for bricks.

**Module IV**
- Ferrous metals and alloys - pig iron, cast iron, wrought iron – types, properties; steel – properties, types, market form of steel and uses of steel in construction, properties of mild steel and hard steel, defects in steel, steel alloy.
Module V  Ceentitious materials:
Lime - classification of lime, fat and hydraulic lime – properties and use;
cement: composition of ordinary cement; function of cementing ingredients;
properties of cement – fineness, soundness, setting times, etc; grades of cement
and different types of cements used in construction; storage of cement in site.

Module VI  Mortars: types of mortar – lime mortar, mud mortar, lime-surkhi mortar, cement
mortar; different grades of mortar, their compositions and properties;
preparation of cement mortar; use and selection of mortar for different

Module VII  Sand - sources of sand, classification, test of sand; grades of sand and their uses

Module VIII  Concrete - compositions and grades of concrete; various steps in concrete
construction – batching, mixing, transporting, compacting, curing, shuttering,
jointing, tests and quality control of concrete.

Essential readings
International.

Supplementary readings
New Delhi: Dhanpat Rai Publications.
New Delhi: Pearson Education India.

2. Second Semester

<table>
<thead>
<tr>
<th>PA1102</th>
<th>Architectural Design – I</th>
<th>Credits: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To understand the techniques of architectural drawings and representation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>To design simple architectural elements based on concepts of composition, aesthetics and functionality.</td>
<td></td>
</tr>
<tr>
<td><strong>Module I</strong></td>
<td>Introduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architecture as a profession and role of an architect; contribution of architecture towards society; building process and the architect’s role; processes involved in initiating and completion of an architectural project, architectural services rendered by an architects and disciplines needed to</td>
<td></td>
</tr>
<tr>
<td><strong>Module II</strong></td>
<td>Measured Drawing</td>
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<tr>
<td></td>
<td>Selecting any existing building structure, conducting a detailed measurement exercise, representing the same as architectural drawings in an appropriate</td>
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</tr>
<tr>
<td><strong>Module III</strong></td>
<td>Anthropometry</td>
<td></td>
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<tr>
<td></td>
<td>Understanding the human proportions, human functions and their implication of space standards; deriving habitable space standards through</td>
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<tr>
<td><strong>Module IV</strong></td>
<td>Clustering</td>
<td></td>
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<tr>
<td></td>
<td>Understanding the spatial requirement for human habitation; taxonomy of spaces through classification of activities; transformation of forms to built spaces, understanding the nature of space, their connectivity, and deriving various spatial clusters to fulfill spatial requirement for better quality of human life; application of principles of design to design simple building elements (e.g.</td>
<td></td>
</tr>
<tr>
<td><strong>Module V</strong></td>
<td>Analogy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Understanding the concept of analogy and application of analogical thoughts in architectural design</td>
<td></td>
</tr>
<tr>
<td><strong>Module VI</strong></td>
<td>Design assignment - guard room/ bus stand/public toilet/small specialized shop (florists/cafe)</td>
<td></td>
</tr>
</tbody>
</table>

**Supplementary readings** As suggested by the studio incharge

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<table>
<thead>
<tr>
<th>Module I</th>
<th>Introduction of Sections; Section of solids – true shape of section using auxiliary planes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module II</td>
<td>Development of surface (preparation of physical models using surface)</td>
</tr>
<tr>
<td>Module III</td>
<td>Preparation of physical models using surface development (cube, cone, frustum, cylinder, pyramid)</td>
</tr>
<tr>
<td>Module IV</td>
<td>Introduction to intersection of different solid objects; showing intersection lines and projection of views</td>
</tr>
<tr>
<td>Module V</td>
<td>Introduction to Isometric projection, Axonometric projection and Oblique projection of solid objects. Derivation of three dimensional projection/views from two dimensional drawings using different geometrical methods.</td>
</tr>
</tbody>
</table>

**Supplementary readings** As suggested by the studio incharge

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**PA 1302**

**Objective** To be able to draw the various details of construction techniques used in building architecture

<table>
<thead>
<tr>
<th>Module I</th>
<th>Brick construction – types of brick, their dimensions and definitions, types of bonds in brickwork, foundations, buttresses, arches and lintels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module II</td>
<td>Stone construction – types of walls, bonds, arches and lintels; foundation – functions of foundations</td>
</tr>
<tr>
<td>Module III</td>
<td>Foundation – types of foundations, simple load bearing foundations in brick and</td>
</tr>
<tr>
<td>Module IV</td>
<td>Concrete blocks – hollow and solid, stabilised mud blocks</td>
</tr>
<tr>
<td>Module V</td>
<td>Timber work - simple carpentry joineries</td>
</tr>
<tr>
<td>Module VI</td>
<td>Different types of timber doors and windows, fixing details of frame, style, rail, panel, glazing including fixtures and fastenings</td>
</tr>
</tbody>
</table>

Supplementary readings


**PA 1402 Visual Arts II**

<table>
<thead>
<tr>
<th>Objective</th>
<th>Credits: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To recognize the systematic and technical processes of creation of visual artifacts in different media and understand visual art in the</td>
</tr>
<tr>
<td><strong>Module I</strong></td>
<td><strong>FORM GENERATION</strong></td>
</tr>
<tr>
<td>Lecture demonstration: Introduction to elements of form and rules of composition Exercises: Additive form generation using surface developments; Moulded and subtractive form generation using plaster or clay</td>
<td></td>
</tr>
<tr>
<td><strong>Module II</strong></td>
<td><strong>RENDERING IN WATERCOLOUR</strong></td>
</tr>
<tr>
<td>Lecture demonstration: Introduction to the medium and tools Exercises: Painting from imagination; Painting from life; Painting from reference images</td>
<td></td>
</tr>
<tr>
<td><strong>Module III</strong></td>
<td><strong>PHOTOGRAPHY</strong></td>
</tr>
<tr>
<td>Lecture demonstration: Introduction to the mechanism of a camera, focal length and lens types, exposure and its control, shutter speed, aperture, depth of field, ISO, light conditions; Parameters of digital raster images and introduction to basics of post-processing using digital suites like Corel Photopaint or Adobe Photoshop Exercises: Photographing still life/ landscapes/ portraits/ architecture/ abstracts; Using photography to represent a theme; Creative post-processing</td>
<td></td>
</tr>
<tr>
<td><strong>Module IV</strong></td>
<td><strong>DIGITAL ART</strong></td>
</tr>
<tr>
<td>Lecture demonstration: Introduction to the basics of vector graphics using digital suites like Corel Draw or Adobe Illustrator Exercises: Developing graphic designs for posters/ brochures/ portfolios/ illustrations; Using vector graphics for rendering</td>
<td></td>
</tr>
<tr>
<td><strong>Module V</strong></td>
<td><strong>REVIEW OF WORLD ART</strong></td>
</tr>
<tr>
<td>Lecture demonstration: Orientation for art appreciation; Exposure to, and consideration of, prominent works of art, from around the world, through the ages Exercises: Critical short essay on any selected piece of art</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings:** None

**Supplementary readings:**

### PA1902 - Model Making Studio

**Objective:** To learn the techniques of making conceptual models in materials like paper, plaster of Paris, timber, etc.

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to three dimensional forms. Creating solid 3D models such as cubes, pyramids, cones etc. using different types of materials such as paper, card board, mount board, wax etc.</td>
</tr>
<tr>
<td>II</td>
<td>Introduction to Joints – different types of joints, joinery details (which are commonly used in timber construction and interiors);</td>
</tr>
<tr>
<td>III</td>
<td>Engraving and carving using soap or Plaster of Paris</td>
</tr>
<tr>
<td>IV</td>
<td>Wire sculptures using different types of binding wires</td>
</tr>
</tbody>
</table>
| V      | Paper crafts –  
- Origami using A4 size sheet  
- Paper lamps using cardboards, ivory sheets, textured sheets, wires or |
| VI     | Multi-purpose furniture for domestic and industrial purpose - independent use of any materials |
| VII    | Clay model workshop – Masonry construction – walls, arches and corbel / Post modern architecture |

**Essential readings:** None  
**Supplementary readings:** None

### PA1304 - Building Construction Lab

**Objective:** To give an introduction to various building materials used in construction and to learn the various details of construction techniques used in building

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Study of various building materials, fittings, fixtures, fastenings used in construction</td>
</tr>
<tr>
<td>II</td>
<td>To prepare brick walling using different brick bonds of different thicknesses</td>
</tr>
<tr>
<td>III</td>
<td>To prepare brick arches and lintels</td>
</tr>
<tr>
<td>IV</td>
<td>To prepare models related to various structural building components and structural systems</td>
</tr>
</tbody>
</table>


### PA1306 - Building Construction - I

**Objective:** To understand the construction techniques used in building design

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Introduction to various building components from foundation to roof and their function; introduction to load transmission in load bearing &amp; framed structures, their advantages, disadvantages and suitability; various types of load bearing and framed structures, their advantages, disadvantages and suitability</td>
</tr>
</tbody>
</table>
Module II
Masonry construction:
Brick construction – types of brick, their dimensions and definitions, types of bonds in brickwork, foundations, buttresses, arches and lintels;
Stone construction – types of walls, bonds, arches and lintels;

Module III
Concrete blocks – hollow and solid, stabilised mud blocks

Module IV
Timber work - simple carpentry joineries and their uses

Module V
Different types of timber doors and windows, fixing details of frame, style, rail, panel, glazing including fixtures and fastenings

Module VI
Foundation – functions of foundations, types of foundations, simple load bearing foundations in brick and stone

Essential readings

Supplementary readings

PA 1502 Evolution of Architecture II Credits: 2

Objective To understand the evolution of Indian architecture starting from Indus Valley civilization up to Mughal period through the context, intentions, strategies, and relevance of different architectural movements, and

Module I
Prehistoric architecture – brief description of Indus valley civilization and its context (social, religious, economic and geographic background), building materials and construction techniques adopted; later Vedic settlements –

Module II
Buddhist architecture and its context, rock cut architecture and building types and other architectural features (rock cut caves, stupas, viharas, chaityas etc)

Module III
Hindu temple architecture and its key elements, evolution of temple form, classification of Hindu temples – North Indian temple architecture (Nagara architecture of Khajuraho temples, Orissan temple architecture, Māru-Gurjara temple architecture of Gujarat)

Module IV
Hindu temple architecture and its key elements, evolution of temple form, classification of Hindu temples – Dravidian architecture of Pallavas, Cholas, Chalukyas, Pandyas, Madura and Vijaynagar dynasties

Module V
Indo-Islamic architecture and its context, major building types (tombs and mosques) and their structural systems (vaults, domes, pendentives etc) and architectural features (jaalis, surface articulation using stones, metal and

Module VI
Indo-Islamic architecture – siteplanning and landscape features, classification of Indo-Islamic architecture of Sultanate period (Slave, Tughlaq and Lodhi) and Mughal period (Babar, Humayun, Akbar, Jahangir and Shah Jahan)

Module VII Seminar presentation on the examples of different architectural styles

Essential Readings
### Building Materials – II PA 1702  
**Credits: 2**

<table>
<thead>
<tr>
<th>Objective</th>
<th>To study the properties of basic building material used in the built environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module I</strong></td>
<td>Non Ferrous Metals and their alloys- Aluminium, Copper, &amp; important alloys like brass, bronze, etc – brief description of uses, Lead and lead-based alloys, nickel and nickel-based alloys; corrosion of both ferrous and non-ferrous metals – types</td>
</tr>
<tr>
<td><strong>Module II</strong></td>
<td>Clay products- tiles, their properties and use - terra-cotta, earthenware, stoneware, porcelain.</td>
</tr>
</tbody>
</table>
| **Module III** | Special concretes and admixtures:  
Admixures: water repellent, waterproofing compounds, accelerators, air entraining agents, hardeners, plasticizers  
Special concretes: light weight concrete, ready-mix concrete, pre-stressed concrete, fibre reinforced concrete and precast concrete |
| **Module IV** | Varnishes, paints, distempers:  
Characteristics and process of varnishing, types and compositions of paints, types of painting system: aluminium paints, cement-based paints, oil emulsion paints, enamel paints, their selection criteria. |
| **Module V** | Heat and sound insulating materials-classification, properties of different heat and sound insulating materials |
| **Module VI** | Misc. materials:  
Use of nano-paints; cork, rubber, gypsum, sealants, asbestos, their trade names and uses; Fly ash, their availability and uses |

**Essential readings**  

**Supplementary readings**  


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3. **Third Semester**

<table>
<thead>
<tr>
<th>PA2101</th>
<th>Architectural Design – II</th>
<th><strong>Credits: 4</strong></th>
</tr>
</thead>
</table>
Objective
To carry forward knowledge gained in the previous semesters.
To introduce the design requirements of a space for human habitation and assimilation of architectural design principles.
To anticipate user needs through personal experience and/or case studies and/or study of vernacular architecture, and translate those into space program. To have basic understanding of the climatic and geographical context of the site and interpreting the information for design development.
To understand spatial components, space standards, basic building services and city specific building bye-laws pertaining to site.
To understand the management of the building site and implementing the basic principles of site management.
To understand the use of bricks and concrete as building material and implementing relevant construction technology.
To acquire manual drafting and presentation skills

Module I
Residential bungalow for single family use (the professional or socio-economic background of the user family may be varied)

Module II
Cafeteria, community market complex, recreational club, community health centre, veterinary dispensary

Essential readings
None

Supplementary readings
As suggested by the studio instructor

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA2201</td>
<td>Architectural Graphics III</td>
<td>2</td>
</tr>
</tbody>
</table>

Objective
To comprehend and draw (by hand) different three dimensional objects/spaces using perspective projection and sciography.

Module I
To comprehend and draw different three dimensional objects/spaces using perspective projection and sciography manually.

Module II
Perspective views of simple and complex geometrical forms (one point, multi-point perspective); views of buildings and objects from different viewing angles.

Essential readings

Supplementary readings

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA 2301</td>
<td>Building Construction Sessional-II</td>
<td>2</td>
</tr>
</tbody>
</table>

Objective
To be able to draw the various details of construction techniques used in building architecture.

Module I
Stairs: requirements of staircase, types of staircases, construction methods of – masonry staircase, timber staircase, RCC staircase, steel staircase and
Module II

Module III
Roof trusses - timber and steel trusses, types, fixing details showing purlin, rafter, tie, strut, cleat etc. different types of roof coverings: for flat and sloped roof with

Module IV
Ground floors: general character and construction process of flooring like: mud flooring, murrum flooring, brick flooring, IPS flooring, stone flooring - marble, granite, tandur/kota stone flooring, terrazzo flooring, mosaic flooring, PCV flooring, ceramic tiles and wooden flooring

Essential readings

Supplementary readings

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PA 2303
Building Construction - II
Credits: 2

Objective
To understand the construction techniques used in building design

Module I
Stairs: requirements of staircase, types of staircases, construction methods of – masonry staircase, timber staircase, RCC staircase, steel staircase and

Module II

Module III
Roof trusses - timber and steel trusses, types, fixing details showing purlin, rafter, tie, strut, cleat etc. different types of roof coverings: for flat and sloped roof with

Module IV
ground floors: general character and construction process of flooring like: mud flooring, murrum flooring, brick flooring, IPS flooring, stone flooring - marble, granite, tandur/kota stone flooring, terrazzo flooring, mosaic flooring, PCV flooring, ceramic tiles and wooden flooring

Essential readings

Supplementary readings

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PA 2501
Evolution of Architecture III
Credits: 2

Objective
To understand the global evolution of architecture from the Industrial Revolution through the contemporary era, recognizing the context, intentions, strategies, and relevance of different architectural paradigms, movements, and styles
<table>
<thead>
<tr>
<th>Module I</th>
<th>ENLIGHTENMENT, INDUSTRIAL REVOLUTION &amp; EARLY MODERN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture demonstration: The techno-economic milieu of late 17th to 19th Century; Neo-classical and Gothic Revival versus early iron and concrete construction, International Expositions, Paxton, Eifel, Beaux Arts to French Rationalism of Labrouste; Late 19th to early 20th century responses to the emerging Modern world; Chicago School &amp; Sullivan; Morris and Arts and Crafts Movement; Art Nouveau in Belgium, France, Austria, Spain, Scotland through the works of Horta, Guimard, Olbrich, Wagner, Macintosh, Gaudi; Cubism, Futurism, German Expressionism of Taut, Poelzig, Mendelsohn; De Stijl of Rietveld. Døshurn: Minimalism of Ios; Suprematism of Malevich.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module II</th>
<th>HIGH MODERN &amp; LATE MODERN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture demonstration: Evolution of Wright; Deutscher Werkbund to Bauhaus, Gropius, and Mies, International Modern; Evolution of Le Corbusier, Brutalism, CIAM; Kahn and Late Modernists</td>
<td></td>
</tr>
<tr>
<td>Exercises: Seminar on selected works of Modern Masters like Behrens, Fuller, Candela, Nervi, Breuer, Neutra, Schindler, Neimeyer, Costa, Johnson, Rudolph, Utzon, Saarinen, Tange, Kurokawa, Isozaki, Otto, et al.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Module III</th>
<th>MODERN PLURALISM, POST-MODERN, HI-TECH &amp; NEO-MODERN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture demonstration: Critical Regionalism and Modernist Pluralism through the works of Aalto, Barragan, Ando, Bawa; Post-Modern Historicism, Rhetoric, Neo-vernacular, Kitsch and Pop, Deconstruction, Formal Hermeticism; Neo-Modern and Hi-tech architecture</td>
<td></td>
</tr>
<tr>
<td>Exercises: Seminar on selected works of Contemporary Masters like Meier, Pelli, Piano, Rogers, Pai, Foster, Maki, Graves, Moore, Venturi, Stirling, Moneo, Botta, Safdie, Eisenman, Tschumi, Gehry, Hadid, Zumthor,</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings**


**PA2601**  
**Building Services – I**  
**Credits: 2**

**Objective**
To understand the quantitative, qualitative, and spatial requirements of a building in terms of its water supply and sanitation needs

**To understand the practical application water supply and sanitation systems of a building**

**Module I**  
**Introduction to Water Supply System**
Introduction - government provisions for water supply in India, definition of ‘water’, quality criteria, standards of purity; water supply for urban community - sources of water and methods of collection, impurities in water, standards for water demand, calculation of water demand, fire demand, swimming pool water quality; water purification systems for urban community, conventional water treatment methods, modern water treatment methods, water reservoirs, distribution systems, distribution networks.

**Module II**  
**Water Supply System for a Building**
Domestic water demand, design of overhead and underground water tank; municipal water supply connection - house/service connection, water meter; domestic water supply system - cold water supply system, hot water supply system, water heating system, water distribution system for multi-storeyed, water supply pumping mechanism; domestic water supply pipe design - basic principles of pipe flow, design of water supply pipes, materials of water supply pipes and fittings, classification, and sketches, colour coding for pipes; water supply appurtenances – specification, and sketches.

**Module III**  
**Practical application of Module I and Module II**
Water supply system for buildings, complete with layout drawings, with consideration of Indian Standards for water supply convenience and National Building Bye laws

**Module IV**  
**Sanitation System for a building**
Introduction - government provisions for water supply in India, characterisation of waste, volume of waste, basic principle of building sanitation and disposal of waste; sanitary fixtures – soil fixtures, water fixtures, material of sanitary fixtures; traps – as per shape, as per function, as per location; material for sanitary pipelines; plumbing system of a building; Stack capacity – basic principles of stack flow, determination of stack sizes for a building, determination of sanitary pipe sizes for a site; connection of house sewers to municipal sewers, ventilation of sewers; basement drainage and its design consideration.

**Module V**  
**Sewerage system for an urban community**
Methods of sewage collection - systems of sewage conveyance; patterns of collection system; sewer lines – factors affecting the quantity of sewage, determination of volume of sewage, shape of sewers, design of sewer lines, partial flow diagram, Manning’s formula, materials for sewer lines, sewer joints and bends; laying of sewers and drains, testing of sewers and drains; surface drainage system; sewer appurtenances; conventional sewage treatment methods; sewerage for isolated building - different types of privies; Imhoff tank; Septic tank – details and design of a septic tank.

**Module VI**  
**Practical application of Module IV and Module V**
Sewerage system for buildings, complete with layout drawings, with consideration of Indian Standards for sanitary convenience and National Building Bye laws.

**Essential**
Objective   To study the factors of climate affecting the building and to be able to design the building as per the climatic condition of site

Module I   Introduction - climate and weather, elements of climate, classification of tropical climates, site climate; thermal comfort factors- thermal balance of a body, subjective variables; thermal comfort indices- effective temperature, heat stress index, the bioclimatic chart;

Module II   Measuring weather data at nearby places using weather station/instruments;

Module III   Thermal quantities- heat flow rate, conductivity, conductance, multilayer body, transmittance, convection, radiation, sol-air temperature, solar gain factor; heat exchange of buildings- conduction, convection, radiation, internal heat gain, heating and cooling, evaporation, heat loss calculation, heat gain calculation, thermal gradient, thermal design; periodic heat flow- steady state assumption, thermal diffusivity, periodic heat flow calculation;

Module IV   Structural controls- thermal insulation, thermal capacity, solar control, orientation, internal blinds and curtains, heat absorbing glasses, angle of incidence, shadow angle, shading devices, design of shading devices; ventilation and air movement- convective cooling, stack effect, wind effect, air flow through buildings, orientation, external features, cross- ventilation, position of openings, size of openings, controls of openings, air movement and rain, air flow around buildings, humidity control;

Module V   Application- shelter for hot-dry climate, shelter for warm-humid climate, shelter for composite climate, shelter for tropical upland climate

Module VI   Case-studies- Case-study of climate responsive architecture in hot-dry, warm-humid, cold- sunny, cold-cloudy and composite climate


1. Fourth Semester

PA2102  Architectural Design – III  Credits: 4

Objective
To carry forward knowledge gained in the previous semesters.
To understand the requirement of a space for multiple users and assimilating those with architectural design principles.
To focus on a design theme/concept and translating it into architectural design. To understand the site and the context (physical and social) as source of design concept and design decisions.
To incorporate climate responsive strategies into building design
To introduce and incorporate barrier free design strategies in building design
To incorporate detailed building services requirements with detailed calculation
To explore other building materials for construction and to understand and detail out the relevant construction technology.

Module I
Youth hostel, school for physically challenged, meditation and spiritual centre, higher secondary school (non residential)

Module II
Motel, student activity centre

Essential readings  None
Supplementary readings  As suggested by the studio instructor

PA2202  Computer Aided Design & Simulation – I  Credits: 2

Objective
To be able to draft the basic 2D & 3D geometry in computer aided design software.

Module I
AutoCAD 2D Basic - Drawing tools, modifying tools, array, working in layers, line type, line thickness, line type scale, colouring, hatching, block making, annotation, dimensioning; AutoCAD 2D Advanced- Viewports, UCS icon, Paper space& model space, sheet layout, micros, customized interface, customized line-type, customized hatch pattern; Digitization of hand drafted sheets of previous semester.

Module II
AutoCAD 3D Basic- Basic objects, extrude, sweep, revolve, changing UCS, working in various views.

Module III
Developing of 3D models in AutoCAD of previous semester design project, AutoCAD 3D - Materials, Lighting, Rendering.

Module IV
Submissions/ Viva/ Test.

## PA2302  Building Construction Sessional III  Credits: 2

<table>
<thead>
<tr>
<th>Objective</th>
<th>To be able to draw the various details of construction techniques used in building design.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I</td>
<td>Study of principles and methods of construction of RCC structure: beams including cantilever beams, columns, slabs including one way, two way and cantilever slabs, roof including vaults and domes; form-work techniques and construction details.</td>
</tr>
<tr>
<td>Module II</td>
<td>Shoring and its types; underpinning; scaffolding and its application.</td>
</tr>
<tr>
<td>Module III</td>
<td>Expansion joints - construction details at foundation, walls, floors and roof level for both concrete and brick work.</td>
</tr>
<tr>
<td>Module IV</td>
<td>Construction of upper floors: timber floor, flag stone floor on steel joist, jack arch floor, reinforced cement concrete floor including flat slab construction, ribbed floor and precast concrete floor.</td>
</tr>
<tr>
<td>Module V</td>
<td>Water proofing at flat roof and damp proofing at basement.</td>
</tr>
<tr>
<td>Module VI</td>
<td>Plaster – method of plastering; internal plaster (use of various finishes viz., lime, cement, plaster of Paris); external plaster (smooth, rough, textured, grit plaster); cladding – types and method of construction.</td>
</tr>
<tr>
<td>Module VII</td>
<td>Mild steel and aluminium doors and windows; partitions - wooden/steel/aluminium; sliding and folding doors; steel doors for garages and workshops, collapsible gate and rolling shutters; fixing details of steel and aluminium sections at jamb, sill, head / lintel; structural glazing, FRP, etc.</td>
</tr>
<tr>
<td>Module VIII</td>
<td>Fire resistive construction for different components of a building.</td>
</tr>
<tr>
<td>Module IX</td>
<td>Cost Effective Construction Technologies (CECT) in building construction: foundation, walls including rat-trap bond, brick arches (at lintel level), roof including filler slab and use of ferro-cement.</td>
</tr>
</tbody>
</table>

### Essential readings


### Supplementary readings


## PA2902  Architectural Tour and Field Study I  Credits: 1

<table>
<thead>
<tr>
<th>Objective</th>
<th>To be able to appreciate the architectural monuments and buildings of historical significance.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I</td>
<td>Field study tour of historical buildings (preferably including examples of Hindu, Islamic and Modern architecture) and collection of data/measurements for those buildings.</td>
</tr>
<tr>
<td>Module II</td>
<td>Submission of measured drawings and report on historical buildings visited with detailed presentation.</td>
</tr>
</tbody>
</table>

### Essential readings

As suggested by Professor-in-charge

### Supplementary readings

As suggested by Professor-in-charge
<table>
<thead>
<tr>
<th>Module I</th>
<th>Study of principles and methods of construction of RCC structure: beams including cantilever beams, columns, slabs including one way, two way and cantilever slabs, roof including vaults and domes; form-work techniques and reinforcement details.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module II</td>
<td>Expansion joints - construction details at foundation, walls, floors and roof level for both concrete and brick work.</td>
</tr>
<tr>
<td>Module III</td>
<td>Construction of upper floors – general considerations; timber floor; flag stone floor on steel joist; jack arch floor; reinforced cement concrete floor including flat slab construction, ribbed floor and precast concrete floor.</td>
</tr>
<tr>
<td>Module IV</td>
<td>Water proofing at flat roof and damp proofing at</td>
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<td>Module V</td>
<td>Plaster – method of plastering; internal plaster (use of various finishes viz., lime, cement, plaster of Paris); external plaster (smooth, rough, textured, grit plaster); cladding – types and method of construction.</td>
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<tr>
<td>Module VI</td>
<td>Mild steel and aluminium doors and windows; partitions - wooden/steel/aluminium; sliding and folding doors; steel doors for garages and workshops, collapsible gate and rolling shutters; fixing details of steel and aluminium sections at jamb, sill, head / lintel; structural glazing, FRP, Fire resistive construction for different components of a building.</td>
</tr>
<tr>
<td>Module VII</td>
<td>Introduction to Cost Effective Construction Technologies (CECT) in building construction- foundation, walls including rat-trap bond, brick arches (at lintel level), roof including filler slab and use of ferro-cement.</td>
</tr>
<tr>
<td>Module VIII</td>
<td>Case study (or study on the application of the construction techniques in buildings) on any topic from the above mentioned modules by the students. Submission of report along with oral and visual presentation.</td>
</tr>
</tbody>
</table>

**Essential readings**


**Supplementary readings**

<table>
<thead>
<tr>
<th>Module I</th>
<th>COLONIAL ARCHITECTURE IN INDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture demonstration: The dawn of colonialism in India; Portuguese, Dutch, French, and English settlements; European identities evidenced in Colonial architecture and Hybridism, as in Franco-Tamilian houses; Evolution of the English architectural style in India; The tradition of Indian architecture in the Colonial era, architecture of the princely states, efforts of Jacob and Growse.</td>
<td></td>
</tr>
<tr>
<td>Exercises: Seminar on selected colonial architecture from Goa, Daman and Diu, Cochin, Chandernagore, Pondicherry, Calcutta, Mumbai, Madras, New Delhi, et cetera</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Module II</th>
<th>REVIEW OF POST-COLONIAL ARCHITECTURE IN INDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture demonstration: Evolution of contemporary architecture in India, Pre-independence era Nationalism, Post-independence Nehruvian vision and First Generation Modernists, Corbusier and Kahn in India, Second Generation Modernists, The issues of identity and culture and the early Post-Modern turn, Information revolution and Globalisation and the late Post-Modern</td>
<td></td>
</tr>
<tr>
<td>Exercises: Seminar on selected works of architects like Raymond, Stein, Rehman, Gandhi, Kanvinde, Correa, Doshi, Raje, Rewal, Gujral, Sabhiki, Khosla, Patell, Baker, Jain, Sahiba, Anger, D'Cruz, Da Cunha, Kamath, Viswanathan, Kundoo, Mukherjee, Mitra, Mohe, Contractor, Benninger, Puri, Chaudhuri, et al.</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings:**

PA2602  Building Services-II  Credits: 2

Objective: To study the various services used in & around the buildings

Module I: Introduction to Storm water drainage in urban community. Collection and disposal of storm water in building; Run-off co-efficient. Manning’s formula.

Module II: Introduction to solid waste management at urban level. Refuse disposal-sources types collection, storage and transport, provisions for refuse disposal at individual building level, refuse chutes; solid waste treatment.

Module III: Literature study on best practice of solid waste management with seminar (ppt. presentation and report submission)


Module V: Electrical services- electrical fittings and appliances, transformers, MDB, various wiring systems, calculation and distribution of load, safety measures.

Module VI: Telephone and television services

Module VII: HVAC and fire system

Module VIII: Site studies of various electrical systems and wiring services, location of HVAC and fire system. Report submission.

Module IX: Detailed layout of electrical, telephone and television services in a residence.


PA2904  Acoustics and Illumination  Credits: 2

Objective: To understand the basic building science related to acoustics and illumination inside the building and to able to apply the knowledge in architectural design

Module I: Basic theory of sound- frequency, wavelength, velocity, sound spectrum, sensitivity of hearing, inverse-square law, decibel, noise exposure limits, sound level meters, A-Weighted sound level, decibel scales for sound intensity, pressure and power; Sound absorption- sound absorbing treatment, sound absorption coefficient, reverberation room, application of sound-absorbing materials, reverberation time, mass law, effect of stiffness, sound leaks, noise reduction between rooms, STC contour, masking for sound isolation, noise criteria curves, room criteria curves, impact isolation, outdoor barrier for noise control, thin-wall barrier, balconies and overhangs, earth berms, attenuation from vegetation, temperature and wind effect, land use planning for noise control, orientation of buildings; mechanical system noise- basic practice of vibration isolation, rubber mounts, noise source in ducts, fan room treatment, cross talk, air duct layout, isolation hangers; speech privacy-speaker and listener orientation, annoyance, intruding speech, background noise.
Module III  Case-studies on auditorium, dwellings, office, worship places, music performance room, concert hall, etc.

Module IV  Basic concept in lighting, qualities of light sources, lamps, luminaires, lighting controls, quality of light, quantity of light, lighting design approach, lighting design in spaces like residential, work place, classroom, healthcare, retail, hospitality, common spaces, outdoor lighting design,

Module V  Basic principles of daylighting, and daylighting systems; case-study on daylighting and illumination

**Essential readings**


**Supplementary readings**

- Rienstra, S.W., and Hirschberg, A. *An Introduction to Acoustics*. Eindhoven

### 5. Fifth Semester

**PA3101 Architectural Design – IV Credits: 6**

Objective

To carry forward knowledge gained in the previous semesters.

To design a multifunctional public building set in a particular context and develop a comprehensive space program and design methodology.

To understand the relationship between the building, the site and surrounding built/un-built environment

To introduce element of landscaping and design for the outdoor environment and incorporating them through site development

To implement in detail strategies of climate responsive architecture with analysis.

To introduce energy efficient architecture

To understand, in detail, the advanced building services and incorporating those in the building design (including detailed analysis and calculation)

To understand the relation between building interior, structural system and the service core.

Detailed implementation of city specific urban development controls, building byelaws and the National Building Code (as and when revised).

To explore advanced building materials and construction technology. To develop skills for computer aided design simulation and rendering To conduct in-depth literature studies

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Module I  Interpretation centre, vocational training centre, gymnasium/fitness centre, nodal development centre for a rural region

Module II  High rise residential building (stand alone)

**Essential readings**  None

**Supplementary readings**  As suggested by the studio instructor
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA3201</td>
<td>Working Drawing-I</td>
<td>2</td>
</tr>
<tr>
<td>PA3203</td>
<td>Computer Aided Design and Simulation-II</td>
<td>2</td>
</tr>
<tr>
<td>PA3205</td>
<td>Advanced Rendering Studio</td>
<td>1</td>
</tr>
</tbody>
</table>

### Objective
- **PA3201**
  - **Working Drawing-I**: To be able to draw the professional drawings of the building design
  - **Module I**: Introduction to the concept of professional working drawing practices; detail construction drawing as per contract documents with proper dimensioning and labelling; suggested building types - Plotted residential building or villa or bungalow. Layout plan showing details of internal roads, excavation plan, foundation plan and details, plinth layout; Floor plans, terrace plan showing elevations of the building showing all details on the external surface, sections through toilets, staircases and any critical areas; Door window schedule, staircase details.
  - **Module II**: Introduction to sanction drawing, completion drawing.
  - **Supplementary readings**: None

- **PA3203**
  - **Computer Aided Design and Simulation-II**: To be able to draw 3D objects in Building Information Modelling (BIM) and other 3D software
  - **Module I**: Basic tools of Autodesk Revit Architecture - getting acquainted with the Revit interface and file types, views, modelling basics, modifying elements.
  - **Module II**: Advanced tools of Autodesk Revit Architecture - extended modelling, working with other CAD applications, preparing documents for clients, schedule, sheets, annotations, construction documentation, printing, family creation, conceptual modelling, rendering, walkthrough.
  - **Module III**: 3Ds Max Design - basic commands of 3Ds Max, import of 3D model from CAD environment, material, light, rendering, walkthrough, animation.
  - **Module IV**: Google Sketch Up - basic drafting, materials, rendering, import and export to and from other CAD platforms.
  - **Supplementary readings**: Stine, D. J. (2013). *Commercial Design Using Autodesk Revit Architecture*.

- **PA3205**
  - **Advanced Rendering Studio**: To be able to create well-rendered presentations, involving both two dimensional drawings and simulated three dimensional views, with the help
Module I  DIGITAL RENDERING OF DRAWINGS
Lecture demonstration: Basics of the digital media; Operating digital rendering suits like Corel Draw/Adobe Illustrator for vector drawings, and Corel Photopaint/Adobe Photoshop for raster images; Optional introduction of other 2D rendering suits
Exercises: Rendering scaled plans, elevations, sections, and sheet layouts for

Module II  DIGITAL RENDERING OF SIMULATED 3D MODELS
Lecture demonstration: Modelling in SketchUp and rendering SketchUp Models through V-Ray/Kerkythea; Optional introduction of other modeling and 3D rendering suits; Development of simple walk-through videos
Exercises: Rendering day/night views of exteriors/interiors of existing design and simple walk-through videos

Essential readings  None
Supplementary readings  None

PA 3901  Interior Design  Credits: 2
Objective  To understand the various elements and aspects involved in the designing of interior spaces, and to be able to implement the knowledge

Module I  ELEMENTS OF INTERIOR DESIGN
Lecture demonstration: Interior layouts considering functional and perceptual aspects; Treatment of the envelope – walls, floors, ceilings, fenestration, etc., with different materials such as paint, stone, timber, glass, metal, ceramic, fabric, composites, etc., and their joinery/installation parameters; Dimensional and material requirements of furnishing, innovative space-saving designs; Interior lighting, illuminants and luminaires; Indoor plants; Signage and decorative objects; HVAC and safety systems
Exercises: Inventory of various commercially available products and materials for flooring, wall cladding, false ceilings, furnishing, lighting, decoration, etc.

Module II  INTERIOR DESIGN STYLES
Lecture demonstration: Introduction to stylistic elements of interiors from different cultures and periods
Exercises: Development of interior design scheme of a restaurant/hotel foyer/guest room/retail store/office/residence etc., following a stylistic

Essential readings  None

PA 3801  Landscape Design  Credits: 2
Objective  To understand the various elements and aspects involved in the designing of landscapes

Module I  ELEMENTS OF LANDSCAPE DESIGN
Lecture demonstration: Hard and soft landscaping; Soil and landform; Water features, irrigation, and drainage; Plant classification, inventory, and use; Pavements and ground covers, landscape furniture and ornaments, illumination; Typological elements such as plaza, court, promenade, etc., etc.
Exercises: Plant inventory and documentation of landscaping details
Module II  LANDSCAPE DESIGN STYLES
Lecture demonstration: Introduction to various styles of landscape design from different cultures and periods
Exercises: Seminar on different landscape styles

Essential readings None

PA 3903  Housing  Credits: 2

Objective To understand the need for shelter, various issues related to the development of housing system, and policies
To understand the housing practices, and to analyse designed environment

Module I Definition of house and housing, dwelling unit, habitable room, household; definition of built-up area, super built-up area, carpet area, FSI; housing typologies – detached, semi-detached, apartments, row houses
Group study of existing housing typologies in the Institute campus; seminar presentation on the housing typologies present in the Institute campus

Module II Site planning- site analysis, site planning principles; determinants of housing design – social, physical and economical dimensions, housing design guidelines, bye-laws, NBC
Seminar on LIG, MIG, HIG mass housings, and condominiums case studies

Module III Housing need, housing stock, and housing shortage; concept of formal and informal housing; types of formal and informal housing

Module IV Housing affordability; housing finance – financial institutions; housing market; rental housing; Real Estate (Regulation and Development) Act 2016, introduction to housing policies – PMAY, slum rehabilitation and redevelopment, rental housing policy: stakeholder and professional involvement

Module V Concept of core housing, low cost housing, self-help housing, flex housing, and inclusive housing
Seminar on core housing, low cost housing, self-help housing case studies, flex housing

Chattopadhyay, S. *New Essays on Inclusive Housing*. Kolkata: Macmillan Publishers India Ltd.


6. Sixth Semester

PA3102  Architectural Design – V  Credits: 6
### Objective
To carry forward knowledge gained in the previous semesters. To develop a detail scheme for site and crowd management.

To incorporate energy efficient architecture with detailed analysis through theory and computer aided simulation.

To develop the building site through detailed landscape.

#### Module I
Shopping mall, Commercial complex, mixed use

#### Module II
Convention centre, government administrative building (municipality/development authority building)

#### Essential readings
None

#### Supplementary readings
As suggested by the studio instructor

### PA3202 Working Drawing - II Credits: 2

<table>
<thead>
<tr>
<th>Objective</th>
<th>To be able to draw professional drawings of building design and...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I</td>
<td>Building construction drawings to be prepared as per contract documents and following proper nomenclatures of dimensioning and labeling; in continuation to lessons learned in Working Drawing – I, Building</td>
</tr>
<tr>
<td>Module II</td>
<td>Details of toilets (plan, section, elevation, fixture/joinery details); details of kitchen (plan, section, elevation, fixture/joinery details); additional details e.g. carpentry details/ metal finish detail.</td>
</tr>
<tr>
<td>Module III</td>
<td>Layout of plumbing and sanitary lines and their connection to septic tank/main service lines; designing and detailing of a septic tank with soak pit; electric layout of all floors with specification of fixtures; details of Municipal submission drawings.</td>
</tr>
<tr>
<td>Module IV</td>
<td></td>
</tr>
<tr>
<td>Module V</td>
<td>Submissions/ Portfolio</td>
</tr>
</tbody>
</table>

#### Essential readings
Reference materials as per topics &

#### Supplementary readings
Reference materials as per topics &

### PA3902 Architectural Tour and Field Study II Credit: 1

<table>
<thead>
<tr>
<th>Objective</th>
<th>To be able to appreciate the historic and contemporary architectural monuments/ buildings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I</td>
<td>Field study tour of historical buildings (preferably including examples of Hindu, Islamic and Modern architecture) and collection of data/measurements for those buildings.</td>
</tr>
<tr>
<td>Module II</td>
<td>Submission of measured drawings and report on historical buildings visited with detailed presentation.</td>
</tr>
</tbody>
</table>

#### Essential readings
As suggested by Professor-in-charge

#### Supplementary readings
As suggested by Professor-in-charge

### PA 3904 Estimation, Costing, and Specification Laboratory Credits: 2

<table>
<thead>
<tr>
<th>Objective</th>
<th>To understand the process to prepare the specification for a building and to estimate the cost involved in the construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module I</td>
<td>Calculation of excavation (earthwork): estimate of quantity</td>
</tr>
<tr>
<td>Module II</td>
<td>Calculation of concrete work: estimate of quantity</td>
</tr>
<tr>
<td>Module III</td>
<td>Calculation of brick work: estimate of quantity</td>
</tr>
<tr>
<td>Module IV</td>
<td>Calculation of plaster: estimate of quantity</td>
</tr>
</tbody>
</table>
Module V Calculation of finishes – wall, floor, ceiling, roof: estimate of quantity
Module VI Calculation of wood work; calculation of fittings for doors and windows: estimate of quantity
Module VII Calculation of other fittings or fixtures: estimate of quantity
Module VIII Calculation of cost of each material, labour charges for each type of work; Final calculation of total costing of the building

**Essential reading** *Specifications*, Volume 1 and 2, CPWD, Government of India
**Supplementary reading** *Delhi Schedule of Rates*, CPWD

<table>
<thead>
<tr>
<th>PA 3906</th>
<th>Estimation, Costing, and Specification</th>
<th>Credit: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To understand the process to prepare the specification for a building and to estimate the cost involved in the construction</td>
<td></td>
</tr>
<tr>
<td>Module I</td>
<td>Different methods of estimation and terminologies</td>
<td></td>
</tr>
<tr>
<td>Module II</td>
<td>Specification: General specification, Details specification for different building items; structural works, road works.; Analysis of Rate: Analysis of rates for Earth work, Cement concrete, RCC, Brick work, plastering, etc.</td>
<td></td>
</tr>
<tr>
<td>Seminar on market survey of building materials, fittings, and fixtures</td>
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</tr>
<tr>
<td>Module IV</td>
<td>Estimating a project cost: Plinth area method, CBRI method</td>
<td></td>
</tr>
<tr>
<td>Module V</td>
<td>Estimating a project cost: Detailed estimate of quantities</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PA3908</th>
<th>Human Settlements and Vernacular Architecture</th>
<th>Credits: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To understand the context of historical development of human settlements, and to study the changes in city planning over the time To study the vernacular architectural practices, understand their context, and learn the traditional way of constructing buildings in India</td>
<td></td>
</tr>
<tr>
<td>Module I</td>
<td>Definition and origin of vernacular architecture; factors of vernacular architecture; socio-cultural, geographical, climatic and religious influences on vernacular architecture; agency and intention in vernacular architecture; examples from different regions throughout the world</td>
<td></td>
</tr>
<tr>
<td>Module II</td>
<td>Vernacular architecture in India: Seminar presentations on the vernacular architectural practices in different regions in India</td>
<td></td>
</tr>
<tr>
<td>Module III</td>
<td>Brief discussion on neo-vernacular architecture; difference between vernacular and neo-vernacular architecture – agency and intention: explanation with</td>
<td></td>
</tr>
<tr>
<td>Module IV</td>
<td>Census definitions of urban, rural, class VI to class I cities, urban agglomeration, conurbation; process of urbanization – historical perspective</td>
<td></td>
</tr>
<tr>
<td>Module V</td>
<td>Town planning of Indus valley civilization, Mesopotamia, and</td>
<td></td>
</tr>
<tr>
<td>Module VI</td>
<td>Town planning in Classical cities, and medieval cities – determinants and patterns; Town planning in Renaissance and Baroque period – determinants and patterns Students’ seminar</td>
<td></td>
</tr>
</tbody>
</table>
Module VII  Colonial expansion in America and Industrial Revolution – Impact on urbanization and settlement system; Redevelopment of Paris; City Beautiful Movement – Planning of Washington D.C.

   Students’ seminar

Module VIII  Utopian Concept of urban planning – contribution of Patrick Geddes, Garden cities, satellite towns: determinants and patterns

   Student's seminar

Module IX  New Utopian Concept – Le Corbusier, F.L.Wright; Neighbourhood concept – principles

   Students’ seminar


Supplementary readings

<table>
<thead>
<tr>
<th>PA3910 Building Bye Laws and Codes of Practices</th>
<th>Credit: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To learn the building bye-laws imposed by local government and to be able to design the building as per the given bye-laws</td>
</tr>
</tbody>
</table>

Module I  Development control pertaining to residential premises- plotted development, group housing; development control pertaining to non-residential premises- foreign mission, hostel, hotel, motel, guest house, dharmashala, convenience shopping, local shopping, community centre, district centre, sub-central business district centre, CBD, wholesale/ware housing, government office, health services, educational facilities, auditorium, religious premises, security services, post and telegraph office, public and semi-public premises, farm houses, professional activity;

Module II  General building requirement- space requirement for different parts of building, requirement in respect of building site, means of access, exit requirement, open space area and height limitation, lighting and ventilation of room

Module III  Plumbing services- requirement of water supply for various occupancies in buildings, requirement of sanitary fittings and installations for different occupancies in buildings

Module IV  Fire protection and fire safety requirements- procedure for clearance from fire service, renewal of fire clearance, means of access, exit requirement; fire protection requirements- static water storage tank, automatic sprinklers, fire alarm system; fire

Module V  Building services- provision of lifts, basement, service ducts, electrical services, air-conditioning

Module VI  Procedure for obtaining building permit- documents, size of drawing sheets and colouring of plans, key plan, site plan, layout plan, landscape plan, building plan, building plans for multi-storeyed/special buildings, services plan and water supply provisions; signing of plans, notice for alteration, building permit fees, procedure during construction work, notice of completion, occupancy/ completion certificate

Essential readings  BIS, National Building Code, 2016

Supplementary readings  TCPO, Govt. of India, Model Building Bye-Laws, 2016

<p>| PA3912 Theory of Design | Credits: 3 |</p>
<table>
<thead>
<tr>
<th><strong>Objective</strong></th>
<th>To study various Theories of Design and Process and its applications. Understanding and appreciation of principles and percept's of issues related to design in theory and practice. Appreciation of architectural spaces and things with respect to man and his behavior.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module I</strong></td>
<td>What is Designing?; The Designers’ Objectives and Challenges; Is Designing an Art, a Science or a Form of Mathematics?</td>
</tr>
<tr>
<td><strong>Module II</strong></td>
<td>Evolution of Design; History of Design Methodology.</td>
</tr>
<tr>
<td><strong>Module III</strong></td>
<td>Design process – design as a process, different school of thoughts and processes, philosophies and approaches to design and its methodology, stages of design (divergence, transformation and convergence); systematic search (decision system approach, logical certainty); selection of strategies and methods (linear, cyclic, branching, adaptive, incremental, random search)</td>
</tr>
<tr>
<td><strong>Module IV</strong></td>
<td>KISS principles (Kelly Johnson); Affordance (Gibson, Don Norman); User-centered design (John Flach and Cynthia Dominguez); User-centered design (UCD); HCI (Human-computer Interaction); Human-centered design (HCD).</td>
</tr>
<tr>
<td><strong>Module V</strong></td>
<td>Seminars/ Assignments/ Practical</td>
</tr>
</tbody>
</table>

|---|---|

**Supplementary readings**


7. **Seventh Semester**

<table>
<thead>
<tr>
<th><strong>PA4101</strong></th>
<th><strong>Architectural Design – VI</strong></th>
<th><strong>Credits: 6</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To carry forward knowledge gained in the previous semesters. To incorporate detail strategies for sustainable practices. To introduce basic principles of redevelopment projects. To generate superior quality of computer aided design.</td>
<td></td>
</tr>
<tr>
<td><strong>Module I</strong></td>
<td>District level hospital, 5-star hotel, city centre, college/Institute, performance art centre, transport terminal, Exhibition centre/museum, sports facility Group housing/condominium, multi-speciality hospital.</td>
<td></td>
</tr>
<tr>
<td><strong>Module II</strong></td>
<td>Redevelopment of a brownfield site.</td>
<td></td>
</tr>
<tr>
<td><strong>Essential readings</strong></td>
<td>None</td>
<td></td>
</tr>
<tr>
<td><strong>Supplementary readings</strong></td>
<td>As suggested by the studio instructor</td>
<td></td>
</tr>
</tbody>
</table>

| **PA4701** | **Seminar and Technical Writing I** | **Credit: 1** |
**Objective**
To acquaint students with the process of in-depth study on a topic and also present and prepare report on the topic.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Study on any topic from architectural and allied subjects by individual student with oral and visual presentation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module II</td>
<td>Documentation and submission of report on the topic with proper formatting and referencing.</td>
</tr>
</tbody>
</table>

**Essential readings**
As per the topic.

**Supplementary readings**
As per the topic.

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**PA4901** Academic Portfolio  
**Credits:** 2

**Objective**
To compile selected academic, and non-academic projects and prepare portfolio

<table>
<thead>
<tr>
<th>Module I</th>
<th>Identification of academic and non-academic projects to be included in portfolio; Digitisation, and compilation of drawings.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module II</td>
<td>Preparation of portfolio.</td>
</tr>
</tbody>
</table>

**Essential readings**
None

**Supplementary readings**
None

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**PA4301** Advanced Building Materials  
**Credits:** 2

**Objective**
To learn the properties of contemporary materials used in building architecture and to be able to use these materials in professional practice.

<table>
<thead>
<tr>
<th>Module I</th>
<th>Plastics and polymers: General properties of plastics, fillers and plasticizers, molding and fabricating methods for plastics, thermosetting plastics, thermoplastics resins, elastomers or synthetic rubbers, combination of plastic and other materials.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module II</td>
<td>Clay blocks, concrete blocks, other non-clay blocks, blockwork, block paving.</td>
</tr>
<tr>
<td>Module III</td>
<td>Glass: manufacture, non-sheet products, sheet products, glass supporting system.</td>
</tr>
<tr>
<td>Module V</td>
<td>Synthetic boards and composite panels.</td>
</tr>
<tr>
<td>Module VI</td>
<td>Asphalt and bituminous products.</td>
</tr>
<tr>
<td>Module VII</td>
<td>Recycled and ecological materials: Fal-G cement, straw bales, cardboard, clay board and clay plaster, papercrete etc.</td>
</tr>
<tr>
<td>Module VIII</td>
<td>Case study (or study on the application of the materials in buildings) on any topic from the above mentioned modules by the students. Submission of report along with oral and visual presentation.</td>
</tr>
</tbody>
</table>

**Essential readings**
### Supplementary readings

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<table>
<thead>
<tr>
<th>PA 4303</th>
<th>Advanced Building Construction</th>
<th>Credits: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To learn the advanced techniques of construction in building architecture and to be able to apply these learning in solving the architectural construction</td>
<td></td>
</tr>
<tr>
<td><strong>Module I</strong></td>
<td>Introduction to space structures, possibilities in different materials, types of space structures and possibilities in different materials to cover large spans</td>
<td></td>
</tr>
<tr>
<td><strong>Module II</strong></td>
<td>General study of shell structures and folded plate structures in concrete, their types, construction aspects, merits and demerits etc; General study of grid structures and skeletal structures, space frames, domes etc. In steel, their types, construction aspects, merits and demerits etc;</td>
<td></td>
</tr>
<tr>
<td><strong>Module III</strong></td>
<td>General study of suspension structures &amp; catenary structures; Membrane structures and pneumatic structures - types, materials used, merits, demerits and examples</td>
<td></td>
</tr>
<tr>
<td><strong>Module IV</strong></td>
<td>Precast concrete - design considerations and constraints, advantages over cast in situ construction, construction technique, joinery details and application; Modular coordination, RCC fabricated roofing system to cover large span with or without north light, construction of basement in R.C.C; Study of pre-stressed concrete, principles and methods of pre-stressing, systems of pre-stressing, advantages, disadvantages and applications.</td>
<td></td>
</tr>
<tr>
<td><strong>Module V</strong></td>
<td>Temporary structures - materials and techniques used, constructional aspects using timber and steel; general study of construction techniques to cover large spans using short length timber and laminated timber materials, lamella roofing, portal frames, solid beams and web beams.</td>
<td></td>
</tr>
<tr>
<td><strong>Module VI</strong></td>
<td>High-rise building - foundation, structural systems and architectural design considerations; Earthquakes and its effect on buildings, earthquake zones in India, architectural design considerations and constructional detailing for earthquake resistant buildings.</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings**

**Supplementary readings**
### PA4501 Project Management

**Objective**
To understand the risks and responsibilities of architects & project managers and accordingly formulate the schedule of any projects.

**Module I**
Introduction to Project planning; Project participants and project planning process; Work breakdown structure, Project scheduling, Gantt chart, Management of Time, Cost, Labour and Scope; Project planning methodologies-CPM, PDM, PERT, GERT, SLAM, DPM, Critical Chain Planning, etc.; Project Monitoring-Earned Value Analysis.

**Module II**
Tenders- types, tender notice, tender documents, and various procedures; Contract- types, procedures, document, and various conditions of contract with special reference to responsibilities and liabilities of architect, contractor and Dispute resolution mechanism; Introduction to various Acts and Laws related to Arbitration and Conciliation- their proceedings, Arbitration case studies.

**Essential readings**
- PMBOK guidelines

**Supplementary readings** None

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### 8. Eighth Semester

#### PA 4802 Professional Training

**Objective**
To gain a comprehensive learning of architectural practice and its day-to-day requirements from hands-on experience as an intern

**Module I**
PERFORMANCE EVALUATION BY TRAINING AGENCY
The students overall performance during the tenure of internship would be graded by the competent authority at the training agency, following the performance criteria outlined in the Training Manual.

**Module II**
PERFORMANCE EVALUATION BY DEPARTMENT
To be conducted by the department through a viva voce, along with review of deliverables specified in the Training Manual

**Essential readings** None

**Supplementary readings** None

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#### PA 4902 Documentation of Architectural Details of Interest

**Objective**
To be aware of architectural details as may be observed in the day-to-day environment, and to inculcate a habit of observation of the environment, resulting in continual, day-to-day learning

**Module I**
PERFORMANCE EVALUATION BY DEPARTMENT
To be conducted by the department through a viva voce, along with review of deliverables specified in the Training Manual

**Essential readings** None

**Supplementary readings** None

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#### PA 4904 Field Observations

**Objective**

**Module I**
PERFORMANCE EVALUATION BY DEPARTMENT
To be conducted by the department through a viva voce, along with review of deliverables specified in the Training Manual

**Essential readings** None

**Supplementary readings** None
**Objective**

To develop a keen sense of observation of the built-environment, as well as develop analytical capabilities to process the information as learning.

**Module I**

**PERFORMANCE EVALUATION BY DEPARTMENT**

To be conducted by the department through a viva voce, along with review of deliverables specified in the Training Manual.

**Essential readings** None

**Supplementary readings** None

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**PA 4906**

**Site Supervision**

**Credits:** 2

**Objective**

To understand the various elements, aspects, and processes involved in the inspection and monitoring of architectural project sites.

**Module I**

**PERFORMANCE EVALUATION BY DEPARTMENT**

To be conducted by the department through a viva voce, along with review of deliverables specified in the Training Manual.

**Essential readings** None

**Supplementary readings** None

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**PA 4908**

**Critical Appraisal of an Architectural Project**

**Credits:** 3

**Objective**

To be able to critically observe, study, research, analyse, and appraise architectural projects on the basis of relevant criteria.

**Module I**

**PERFORMANCE EVALUATION BY DEPARTMENT**

To be conducted by the department through a viva voce, along with review of deliverables specified in the Training Manual.

**Essential readings** None

**Supplementary readings** None

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9. Ninth Semester

**PA5101**

**Architectural Design VII (urban design)**

**Credits:** 3

**Objective**

To understand the fundamentals of a large scale urban design

To address various urban design issues face in the local area through studio assignment.

**Module I**

**Urban design theories and criticism**

Urban design terminologies and definitions, concept of space and place, History of urban form and space, urban design through history, determinants of urban forms, components of urban structure, concept of layering, urban design policies and practices.

**Module II**

**Planning tools for urban design**

Urban design methodologies, methods of urban design surveys, documentation and representation, introduction to site planning.

**Module III**

**Practical application of Module I and Module II**

Project - Urban design solution for a local area.
### Essential readings


### Supplementary readings

As suggested by the studio instructor

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<table>
<thead>
<tr>
<th>PA5201</th>
<th>Architectural Thesis Research</th>
<th>Credits: 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To collect, and analyse the required data for the synthesis stage of final year thesis project</td>
<td></td>
</tr>
<tr>
<td>Module I</td>
<td>Identification of research area</td>
<td></td>
</tr>
<tr>
<td>Module II</td>
<td>Presentation on: Background, need, aim and objectives of the research, methodological framework of the research; Identification of case studies</td>
<td></td>
</tr>
<tr>
<td>Module III</td>
<td>Presentation on: Literature review and analyses of secondary case studies; Standard study, Study of by-laws and other relevant acts and standards; Tentative area programming</td>
<td></td>
</tr>
<tr>
<td>Module IV</td>
<td>Report submission</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings** As suggested by the instructor

**Supplementary readings** As suggested by the instructor

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<table>
<thead>
<tr>
<th>PA5601</th>
<th>Advanced Building Services</th>
<th>Credits: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To learn the advance services related to building architecture and to be able to apply these learning in professional practice.</td>
<td></td>
</tr>
<tr>
<td>Module I</td>
<td>Mechanical ventilation - study of Air Conditioning systems and their applicability; components of AC’s systems such as chilling plants; cooling towers; air handling units; calculation of AC loads; air distribution systems;</td>
<td></td>
</tr>
<tr>
<td>Module II</td>
<td>Fire safety- Introduction to fire safety in building, causes of fire in buildings, types of fire, spread of fire, production of smoke and poisonous gases; fire safety and preventive measures, fire fighting regulations with reference to National Building Code, fire escape, stairways and escape routes; dry and wet risers; water demand for fire fighting, storage tanks, fire hydrants; study of fire detection systems, smoke detectors, heat detectors, fire alarms, fire fighting extinguishing systems, automatic sprinkler systems.</td>
<td></td>
</tr>
<tr>
<td>Module III</td>
<td>Vertical transportation - study of elevators and various components, standard space requirements; various types of elevators and architectural implications; study of escalators, their components, arrangements and functioning, space requirement, construction detailing.</td>
<td></td>
</tr>
<tr>
<td>Module IV</td>
<td>Viva/ Seminars/ Assignments.</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings** *National Building Code, 2005, BIS.*


Supplementary readings

*Life Safety Code*, National Fire Protection Association, USA
Nield, D. *Mitchell’s Advanced Building Construction (Components, Services & Finishes)*. Allied Publishers
*Journals, Papers, and reference materials* as per topics & instructor.

### PA5701 Seminar and Technical Writing II Credits: 2

**Objective**
To acquaint students with the process of in-depth study on a topic and also present and prepare report on the topic.

**Module I**
Study on any topic from architectural and allied subjects by individual student with oral and visual presentation.

**Module II**
Documentation and submission of report on the topic with proper formatting and referencing.

**Essential readings**
As per the topic.

**Supplementary readings**
As per the topic.

### PA 5401 Advanced Structural Systems Credits: 2

**Objective**
To learn the advance techniques of construction in building architecture and to be able to apply these learning in solving the architectural construction

**Module I**
Study of structural systems like bulk active structures: study of beams, columns, slabs, structural characteristics, case studies

**Module II**
Study of structural systems form active structures: cables: structural behaviour of cables, cable stayed roofs; arches: structural behaviour of arches, types of arches, comparison of arch and beam, Arch roofs: types and case studies

**Module III**
Vector active structures: triangulation, uses and analysis of trusses, structural characteristics

**Module IV**
Surface active structures: curvatures, surfaces; shells and domes: structural characteristics, case studies; Membrane structures: structural characteristics; Pneumatic structures: types, structural behaviour

**Essential readings**

**Supplementary readings**

### PA5501 Professional Practice Credit: 1

**Objective**
To learn the basic responsibilities and liabilities towards the profession, client and society.

**Module I**
Introduction; Nature of profession and its importance in Indian context; The Architect's Act 1972 & its effect on profession and education; Registration of Architect; Code of professional conduct, Architect's liabilities; Consideration of engagement and scale of charges; Architectural Competition guidelines.

**Module II**
Types of Business organizations; The Architect and his organization, objectives, management and administration, job organization and office set up; Fire insurance and Architectural copyright; Easement rights, dilapidations, repairs and fair rent.

**Module III**
Evaluation and Audit of Fire and Life safety design in buildings.
Module IV  Guidelines for Architectural practice policy on practice in a host nation, liabilities of local and foreign architects.

**Essential readings**

**Supplementary readings** None

1. Tenth Semester

<table>
<thead>
<tr>
<th>Architectural Thesis</th>
<th>PA5202</th>
<th>Credits: 10</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>Application of all theoretical and practical knowledge acquired in the previous semesters to design, prepare detailed drawings of a thesis project and preparation of a thesis report</td>
<td></td>
</tr>
<tr>
<td>Module I</td>
<td>Analyses of primary case studies; Site analysis; Final area statement; Zoning; Buble diagram; Concept</td>
<td></td>
</tr>
<tr>
<td>Module II</td>
<td>Single line plans; Sections; Elevations; Block</td>
<td></td>
</tr>
<tr>
<td>Module III</td>
<td>Double line plans; Sections; Elevations, Detail model/ block model+ 3D</td>
<td></td>
</tr>
<tr>
<td>Module IV</td>
<td>Final presentation (sheets): Inferences from secondary and primary case studies, Concept, Final area statement, Zoning and Buble diagram; Double line plans; Sections; Elevations, Detail (if any); 3D views; Detail</td>
<td></td>
</tr>
<tr>
<td>Module V</td>
<td>Final presentation (report)</td>
<td></td>
</tr>
</tbody>
</table>

**Supplementary readings** As suggested by the supervisor

<table>
<thead>
<tr>
<th>PA5902</th>
<th>Comprehensive Viva-Voce</th>
<th>Credits: 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>The comprehensive viva-voce aims to test the holistic comprehension of the student covering all the subjects taught.</td>
<td></td>
</tr>
<tr>
<td>Module I</td>
<td>Entire syllabus (1st to 9th semester)</td>
<td></td>
</tr>
</tbody>
</table>

**Essential readings** None

**Supplementary readings** None

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**Int. MSc**

**DEPARTMENT OF CHEMISTRY**

**Detailed Syllabi**

<table>
<thead>
<tr>
<th>CY 101</th>
<th>CHEMISTRY</th>
<th>3 Credits [2-1-0]</th>
</tr>
</thead>
</table>

**PHYSICAL CHEMISTRY:** Spectroscopy: Interaction of molecules with electromagnetic radiation, rotational, vibrational and electronic spectroscopy, selection rules, basic concepts of emission, absorption and LASER Chemical kinetics: Rate equation, order, molecularity, methods of determination of order of a reaction, examples and rate equations of zero, first, second and pseudo first order reactions, temperature dependence of rate constants, Arrhenius theory, concept of activation energy, significance of catalysts. Electrochemistry: Oxidation-reduction reactions, electrochemical cells, Nernst equation and its significance,
standard reduction potential, calculation of solubility product, mean ionic activity coefficient and pH of aqueous medium, commercial dry cell batteries (alkaline) and hydrogen fuel cells (basic idea).

**INORGANIC CHEMISTRY:** Atomic, molecular chemistry: Schrödinger wave equation (origin of quantization), Interpretation of wave function (radial and angular), Hydrogen atom: concept of atomic and molecular orbitals, Structure, bonding and energy levels of diatomic molecules. Examples \( \text{N}_2, \text{O}_2, \text{CO} \) and HF. Chemical bonding: VB, VSEPR, MO theory, Werner’s coordination theory, Chelate Effect (Metal-EDTA complexes), Crystal field theory: splitting of tetrahedral and octahedral complexes, structural concepts of \( \text{Ni}(	ext{CO})_4, \text{Fe}(	ext{CO})_5 \) and \( \text{Mo}(	ext{CO})_6 \) complexes. Importance of metal ions in biological systems (Mg, Fe & Cu).

**Organic reaction mechanisms & reactive intermediates:** Introduction to Organic compounds, Reactions of aliphatic compounds, Carbocations, carbanions and free radicals (Generation, stability and reactions), substitution (\( S_N1, S_N2, S_Ni \), neighbouring group participation, factor affecting \( S_N \) reaction), elimination (\( E1, E2, E1CB \)) and addition reactions (C-C double bond).

General methods of polymerisation, common types of polymers and their application in daily life.

**Course Outcomes:** This course aims to provide an understanding how fundamental principles of chemistry are related to atomic, electronic and thermodynamic properties of matter. Students would also be able to relate basic chemical principles with materials used in daily life and industry.

**Essential Reading:**

**Supplementary Reading:**

**CY 170 CHEMISTRY LABORATORY**

**1.5 Credits [0-0-3]**

**Academic Group:** Chemistry

**Co-ordinator:**

Determination of Hardness of water, Determination of the amount of Dissolved oxygen in water sample, Estimation of Iron content in the given iron salt solution, Estimation of Calcium in given lime stone sample, Reaction kinetics of Hydrolysis of Ester, Kinematic viscosity of Oil by Redwood Viscometer, Determination of Optical rotation of Sucrose, Partition coefficient of a binary mixture, Conductometric titration of strong acid vs strong base, Potentiometric titration of weak base vs strong acid.

**CY 2101 HYDROCARBONS AND THEIR FUNCTIONAL GROUPS**

**3 Credits [3-0-0]**

**Academic Group:** Organic Chemistry

**Co-ordinator:**

Aliphatic Hydrocarbons: alkanes: Synthesis and reactions, conformational itinerary of alkanes, alkenes: Synthesis and reactions, stereochemistry, addition reaction, Markownikov’s rule, peroxide effect, hydroboration, allylic substitution by NBS, ozonolysis, polymerization, free radical, cationic and anionic including the mechanisms; Dienes: Synthesis and reactions, types, Synthesis of 1, 3-butadiene from 1, 4-Butanediol, 1,2- and 1,
4- diol, reaction of 1, 3-butadiene with electrophiles, Diels-Alder reaction, **Alkynes**: Synthesis and reactions, acidity of alkynes in comparison with alkanes and alkenes, formation of acetylides, ozonolysis and hydroboration, **Aromatic Hydrocarbons**: aromaticity, resonance energy, resonance structures of naphthalene, anthracene and phenanthracene, electrophilic substitution reactions of benzene with mechanism, ortho, para- & meta-directing groups.

**Alcohols**: Synthesis and reactions; **Thiols**: Synthesis and reactions; **phenols**: Synthesis, reactions (Reimer-Tiemann’s reaction. Kolbe’s reaction and Fries rearrangement), Synthesis of resorcinol and napthols (α- and β-).

**Organic Halogen Compounds**: Synthesis and reactions, Substitution (S_N1, S_N2, S_Ni) and Elimination reactions (E1, E2, E1CB) and comparison [Effect of reagents and reaction conditions].

**Carbonyl compounds**: Synthesis (Vilsmeier formylation) and reactions, addition reaction, Aldol condensation, Schiff’s base-hydrazone, oxime, Perkin’s reaction, Cannizzarro’s reaction, acetal Synthesis, base catalyzed halogenations reaction of ketones (Iododform reaction). α,β-unsaturated carbonyl compounds-preparation and properties, Michael addition; KETO- enol tautomerism.

**Carboxylic acid and its derivatives (esters, anhydrides, acid halides, amides)**: Synthesis and reactions.

**Aromatic nitro compounds**: Synthesis, reduction in neutral, acidic and alkaline media, TNT.


**Course Outcomes**: This course provides the basic foundation to understand the higher level of organic chemistry with common organic compounds and their reactivity.

**Essential Reading**:  

**Supplementary Reading**:  

**CY 2201 PRINCIPLES OF INORGANIC CHEMISTRY** 3 Credits [3-0-0]

**Academic Group**: Inorganic Chemistry

**Co-ordinator:**

**Atomic Structure**: de-Broglie matter waves, Uncertainty principle, Schrodinger wave equation, quantum numbers and its significance, Radial and angular wave functions, Radial and angular distribution curves, shape of s, p, d orbitals, Angular and radial nodes, sign of orbitals. Pauli’s exclusion principle, Hund’s rule of maximum multiplicity, Aufbau’s principle and its limitations, Variation of orbital energy with atomic number. **Periodicity of Elements**: Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. Atomic radii (van der Waals), Ionic and crystal radii, Covalent radii (octahedral and tetrahedral), Ionization energy and its applications. Electron affinity, Electronegativity, Pauling’s and Mulliken’s electronegativity scales. **Chemical Bonding**: Ionic bond: types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Structure of NaCl, CsCl, ZnS, TiO_2, CdI_2. Expression for lattice energy. Born equation, polarizability, Fajan’s rule, and its applications. Covalent bonds: Lewis theory, Resonance, VBT, quantum mechanical approach to hybridization, directional characteristics, deduction of geometry by VSEPR method, Bent's Rule, Qualitative treatment of MO theory applied to homo (N_2 vs O_2) and hetero (HF, CO, NO) diatomic molecules. **Coordination Chemistry**: Ligands, coordination numbers, coordination sphere, Nomenclature, Werner’s theory, EAN, Chelates, isomerism in coordination compounds, Valence Bond theory, Crystal Field Theory, octahedral, tetrahedral and square planner complexes, calculation of CFSE in octahedral and tetrahedral geometry. **Bioinorganic Chemistry**: Essential metal ions,
Biological ligands for metal ions, Metal ions specificity, O$_2$ storage/transport: Myoglobin/Hemoglobin.

**Course Outcomes:** The students can apply the fundamental principles of measurement, matter, atomic theory, chemical periodicity, chemical bonding, general chemical reactivity and solution chemistry to subsequent courses in science, engineering, technology, allied sciences and various other related disciplines that depend upon these principles for successful comprehension.

**Essential readings:**

**Supplementary readings:**

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**Course Outcomes:** This course would be able to introduce basic principles of physical chemistry to the undergraduate students. Students are expected to develop an analytical aptitude towards fundamentals of physical chemistry.

**Essential readings:**
1. P.W. Atkins and Julio de Paula, Atkin’s Physical Chemistry, Oxford University Press, 2010

**Supplementary readings:**
1. David W. Ball, Physical Chemistry, Cengage Learning, 2002

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**Course Outcomes:** This course would be able to introduce basic principles of physical chemistry to the undergraduate students. Students are expected to develop an analytical aptitude towards fundamentals of physical chemistry.

**Essential readings:**
1. P.W. Atkins and Julio de Paula, Atkin’s Physical Chemistry, Oxford University Press, 2010

**Supplementary readings:**
1. David W. Ball, Physical Chemistry, Cengage Learning, 2002

**Course Outcomes:** This course enables the students a comprehensive understanding of the basic laboratory techniques like chromatography and purification, etc.

**Essential Reading**

**Supplementary Reading**

**CY 2102 ORGANIC CHEMISTRY: STRUCTURE AND REACTIVITY**

3 Credits [3-0-0]

Academic Group: Organic Chemistry

Co-ordinator:

**Stereochemistry:** Configuration and conformation, Geometrical isomerism, Optical isomerism, Enantiomers, Diastereomers, projection formulae, interconversion of projection formulas, D-L and R-S nomenclature (CIP rules), Erythro and threo nomenclature. dl- and meso compounds, Atropisomerism, Stereospecific and stereoselective reactions, Conformations vs reactivity of cycloalkanes.

**Aliphatic Electrophilic Substitution:** $S_{E1}$, $S_{E2}$, and $S_{Ei}$, factors affecting reactivity, effect of substrate structure, leaving group, and solvent, halogenations of carbonyl compounds, halogenations of sulfoxides and sulfones, aliphatic diazonium compounds, diazo transfer reactions, nitrosation reactions at carbon and nitrogen. Keto-enol tautomerism. Active methylene compounds (ethyl acetoacetate, malonic ester, acetylacetone) in organic transformations.

**Heterocyclic compounds:** Classification, Synthesis and reactions of furan, thiophene, pyrrole, pyridine, indole, quinoline, isoquinoline.

**Organometallic compounds:** Definition with examples, Preparation and synthetic applications of Organomagnesium reagent, organolithium compounds, Organozinc compounds, organocopper compounds, selected Name reactions (Grignard Reaction, Reformatsky Reaction and Gillman reaction) and their application in organic Synthesis.

**Course Outcomes:** The concept of stereoisomerism in the context of organic chemistry (i.e., tetrahedral carbon), recognition and assignment of configuration, separation and analysis of stereoisomers will be discussed. With the continuation of this course, students will transit from memorization to understanding by programmed exposure to integrated problems involving mechanism and multi-step synthetic planning. Towards the final half of this course, heterocyclic and organometallic compounds will be taught and that should enable a transition from simple organic compounds to complex ones.

**Essential readings:**

**Supplementary readings:**
CY 2202  STRUCTURE AND BONDING IN INORGANIC CHEMISTRY  3 Credits [3-0-0]

Academic Group: Inorganic Chemistry

Co-ordinator:

Symmetry and point groups: Symmetry elements and symmetry operations. Special and axial point groups. Bonding: MOT to polyatomic molecules (BeH₂, H₂O, BH₃, CO₂). Hard acid base (HSAB) theory and its applications. Coordination compounds: Overview of Crystal Field Theory (CFT), Spectrochemical Series. Application of CFT: Electronic (Color) and Magnetic properties of co-ordination compounds. John-Teller distortion. Ligand Field Theory (Molecular Orbital Theory) for octahedral, tetrahedral, square planar geometry, Spectrochemical Series based on Molecular orbital theory, Angular overlap method-Strength of interaction between ligand orbitals and metal d-orbitals. LS coupling: Term and Symbol, Microstates and determination of ground state.

Course Outcomes: Student learn certain advanced concepts in inorganic chemistry. In addition, they will learn the importance of various inorganic materials such as organometallic, co-ordination and f-block elements.

Essential readings:

Supplementary readings:

CY 2302  PHYSICAL CHEMISTRY : STRUCTURE  3 Credits [3-0-0]

Academic Group: Physical and Computational Chemistry

Co-ordinator:

Atomic Structure: Hydrogen atom, quantum numbers, probability distribution of electron cloud in hydrogen atoms, orbital and spin angular momentum, spectroscopic term symbols for single electron system and atomic spectra (only fine structure of hydrogen & lithium atom), spectroscopic term symbols for multi electronic atoms (significance of L, S and J) and ground state term symbols Chemical Bonding: Valence bond theory and its limitation, molecular orbital (MO) theory, diatomic and polyatomic systems (concepts of σ, π, non bonded orbitals), effect of conjugation. Molecular Term symbols. Molecular Interactions: Lennard Jones potential, intermolecular forces of attraction, classification of solids in terms of bonding (crystalline and amorphous solids, examples only), metallic bonding, introductory concept of conductors, semiconductors and insulators in terms of band gaps. Molecular spectroscopy: Spectral regions and molecular motions, elementary concepts of rotational (diatomic rigid rotor, selection rules) spectroscopy, molecular vibrations (qualitative treatment of simple harmonic and anharmonic oscillator, selection rules), fundamental modes of vibration (examples of H₂O and CO₂), Raman spectra (brief concept) for molecular vibrations only (examples of H₂O and CO₂), rule of mutual exclusion, electronic spectra (vibronic levels, absorption and emission), Beer-Lambert law, application in simple organic molecules.

Course Outcomes: The course aims to focus on the details of microscopic picture of matter. Student would be expected to develop strong understanding of the macroscopic phenomena from a microscopic or molecular point of view.

Essential readings:

**Supplementary readings:**

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**CY 2702  BASIC PHYSICAL CHEMISTRY LABORATORY  1 Credits [0-0-2]**

**Academic Group:** Physical and Computational Chemistry

**Co-ordinator:**

Accuracy, precession, errors (systematic and random), estimation of errors.

1. Determination of Order for the Persulphate-Iodide Reaction
2. Determination of the rate constant of hydrolysis of an ester in aqueous acidic medium.
3. Conductometric titration of a mixture of strong and weak acid with a strong base
4. pH metric titration of a mixture of strong and weak acid with a strong base
5. Study of the distribution equilibrium of iodine in water/toluene.
6. Adsorption characteristics of acetic acid on charcoal
7. Verification of Beer-Lambert law.
8. Ionization constant of a weak acid (acetic acid).
10. Determination of pKa values of Orthophosphoric acid using pH Meter

**Course Outcomes:** These experiments are intended to acquaint the students with the practice of experimental physical chemistry. The outcomes are to understand the interconnection between experimental foundation and underlying theoretical principles and to develop laboratory skills and get familiar with a variety of physico-chemical measurement techniques.

**Essential Reading**

**Supplementary Reading**

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**CY 2704  FUNCTIONAL GROUP ESTIMATION LABORATORY  1 Credits [0-0-2]**

**Academic Group:** Organic Chemistry

**Estimation of** a) No. of hydroxyl (-OH) groups in alcohols; b) Amide (-CONH₂) groups in amides; c) Keto-enol equilibrium of a keto ester; d) Nitrogen; e) Ascorbic acid from fruit juice; f) no. of methoxy groups.

**Determination of** a) Iodine no. of fat or oil; b) Molecular weight of a substance

**Course Outcomes:** The students will become familiar with various quantitative methods used for analysis of organic compounds.

**Essential Reading:**

**Supplementary Reading:**

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**CY 3401 FUNDAMENTALS OF MATERIALS AND NANO CHEMISTRY**

3 Credits [3-0-0]

**Academic Group:** Environment and Materials Chemistry

**Co-ordinator:**


**Course Outcomes:** Advanced undergraduates and graduate students in chemistry, materials science, and chemical engineering will gain knowledge stepwise from the basic chemistry to problems in materials discovery, design, and characterization, and how materials are used in devices and general technology. This course will also provide the students in-depth understanding of a new hot topic on nanoscience and nanotechnology.

**Essential Reading**

**Supplementary Reading**

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**CY 3201 CHEMISTRY OF ELEMENTS**

3 Credits [3-0-0]

**Academic Group:** Inorganic Chemistry

**Co-ordinator:**

**s and p-Block elements:** Alkali, alkaline-earth metals, Boron family, Carbon family, Nitrogen family, Oxygen family and Halogen family. Structural features and reactivity of S-N heterocycles. **Boran**es: nomenclature of boranes, Wades’ rule of electron counting and other counting rules in boranes, bonding in simple boranes, Carboranes. **d-Block elements** (Transition element): electronic configuration and comparative study of ionic radii, ionization potential, oxidation state, redox potential. **Introductory Organometallic Chemistry:** Definition & nomenclature, Counting Electrons (EAN Rules, 18 electron rule). Bonding and application carbonyl (CO) complexes. The isolobal Analogy. **f-block elements:** spectra and
magnetic properties, redox chemistry. **Nuclear chemistry**: Nuclear reactions, fission, fusion, Neutron activation analysis, isotope dilution analysis, Radiometric titrations, nuclear fuel reprocessing.

**Essential readings:**


**Supplementary readings:**


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**Microscopic view of thermodynamics**: entropy and probability, Boltzmann’s paradox, distribution of molecular states, configuration and weights, molecular partition function, internal energy and statistical entropy. **Solid state chemistry**: arrangements of atoms in 3D, close packing vs simple packing of spheres, introduction of Miller indices (planes and directions) in cubic and hexagonal systems, crystal parameters and seven crystal systems, Bravais lattices (14 types), voids (tetrachedral, octahedral) in hexagonal and cubic systems, radius ratio rules, elementary concepts of X-ray diffractions, Bragg’s equation, interplaner spacings, powder X-ray diffraction patterns by Debye-Scherrer method, difference between powder and single crystal diffraction patterns. **Colloids**: colloidal state, kinetic stability, electrical double layer, concept of electrokinetic potential and applications, optical properties of colloids (scattering). **Liquid surface**: surface tension and interfacial tension, phenomena at curved surfaces (Kelvin equation and its significance), capillary rise, bubbles and sessile drops, contact angles and wetting, concept of surfactants, micelles and self assembly, liquid crystals, emulsion and micro emulsion. **Adsorption**: solid-gas interface, physisorption vs chemisorptions, Adsorption isotherm (Langmuir, Freundlich & BET), mechanisms of heterogeneous catalysis. **Surface analysis**: elementary concepts of interaction of electrons with surface (secondary electrons, Auger effect, photoelectron spectroscopy, low energy electron diffraction), atomic force microscopy (introductory concept).

**Course Outcomes**: The course aims to focus on the details of microscopic picture of thermodynamics. Student would be expected to develop strong understanding of the macroscopic phenomena from a microscopic point of view.

**Essential readings:**


**Supplementary readings:**


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**Academic Group: Inorganic Chemistry**

Co-ordinator:
Identify the presence of each of the following anions: \( \text{SO}_4^{2-} \), \( \text{CO}_3^{2-} \), \( \text{NO}_2^- \), \( \text{Cl}^- \), \( \text{I}^- \), and \( \text{NO}_3^- \), using qualitative analysis. Qualitative tests on 3d-metal ions (Fe, Co, Ni, Cu). Identify the cations and anions in an unknown sample of ionic salts. Preparation and physical properties of inorganic/Organometallic compounds.

**Course Outcomes:** The students will become familiar with broad spectrum of practical skills in identifying the anions and transition metal cations, synthesis and characterization of compound as well as nanoparticles, and also connect with the basics knowledge and theory taught in theory classes.

**Essential Reading**

**Supplementary Reading**

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**CY 3703 CHEMICAL BIOLOGY LABORATORY** *1 Credits [0-0-2]*

**Academic Group:** Inorganic Chemistry

**Co-ordinator:**

**List of Experiments:**
1. Visualization of protein structure by using PYMOL software.
2. Training and preparation of Phosphate buffer of desired pH.
3. To determine the isoelectric point of amino acid –glycine and histidine by titration method.
4. Theoretical estimation of isoelectric point and computing electrostatic surface of proteins by using PYMOL.
5. To estimate the concentration of DNA and protein by spectrophotometric assay.
6. To determine the unknown concentration of protein using Bradford reagent (coomassie brilliant blue G250).
7. Purification of protein by using ion exchange chromatography.
8. To study unfolding of protein by steady state fluorescence spectroscopy.
9. To study unfolding of protein by steady state fluorescence spectroscopy.
10. To estimate of concentration and size of DNA by agarose gel electrophoresis.
11. To distinguish DNA from protein by Bradford reagent, heat and acid.
12. To differentiate D & L-Tryptophan and estimate secondary structures of protein by circular dichroism.
13. To estimate melting temperature of protein by far-UV circular dichroism.

**Course Outcomes:** The course highlights the concept of molecular biology, biochemical techniques and bimolecular spectroscopies. At the end, student will have a real feeling about the biological macromolecules like, protein and DNA. They can visualize, characterize and use these macromolecules (DNA and protein) for more complex biochemical assay.

**Suggested Reading:**
2. Essential Molecular Biology, Volume One, by T.A. Brown.

**Supplementary Reading:**
1. Journal of Chemical Education

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**CY 3102 BIO-ORGANIC CHEMISTRY** *3 Credits [3-0-0]*

**Academic Group:** Organic Chemistry

**Co-ordinator:**

**Carbohydrates:** Classification, Monosaccharides, erythro abd threo diasteromers, epimers, cyclic structures of monosaccarides, mutarotation, reactions of monosaccarides, reducing
and non-reducing sugars, chain-shortening and lengthening of sugars, proof of configuration, determination of ring size, disaccharides and polysaccharides.

**Amino acids**: Classification and nomenclature, configuration, acid-base properties, isoelectric point, synthesis and chemical properties of α-amino acids. **Peptides**: peptide bond, biologically important peptides (glutathione, oxytocin-important functions). Proteins: Classification (Primary, Secondary, Tertiary, Quaternary- definition, examples) Forces that stabilize structure of proteins: H-bonds, hydrophobic interaction, electrostatic attraction, Van der Waal's interaction, dipole-dipole interaction.

**Nucleic Acids**: Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding, structure of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), double helix model of DNA and forces responsible for holding it. Chemical synthesis of mono and tri nucleosides. Chemical Properties: Hydrolysis (acid, alkali), enzymatic hydrolysis of DNA. General structure and types of RNA (tRNA, mRNA, rRNA).

**Natural Products**: Isolation and structure elucidation of Terpenoids (Citral, Geraniol, Menthol), alkaloids (Nicotine, atropine).

**Common drugs and vitamins**: Sulpha drugs, Antimicrobial, Analgesic-anti-inflammatory, Cardiovascular agent, Antihistamines, Antilaproxy and Vitamins.

**Course Outcomes**: Bioactive molecules starting from small amino-acids and carbohydrates to complex terpenoids, drugs and vitamins are part of this course. This course offers a detailed study of their structures, synthetic preparations etc and will enable the students to learn how the reactivity of organic compounds can be used to achieve the ultimate target, i.e. synthesis of the bioactive natural products.

**Essential Reading**

**Supplementary Reading**

**CY 3302 CHEMICAL KINETICS AND PHOTOCHEMISTRY** 3 Credits [3-0-0]

Academic Group: **Physical and Computational Chemistry**

Co-ordinator:

Course Outcomes: The course aims to focus on the details of chemical kinetics, catalysis and electrochemistry. Student would be expected to develop strong understanding about chemical dynamics and electrochemical theories on electrical double layers, electrolytes, cells and electrokinetics by relating theories with applications in practical life.

Essential Reading:
3. An introduction to Electrochemistry, Samuel Glasstone, EAST WEST Press

Supplementary Readings:

CY 3104 FUNDAMENTALS OF POLYMER CHEMISTRY 3 Credits [3-0-0]

Introduction and applications of polymers, molecular weight distributions, various experimental methods (GPC/SEC, solution viscosity, VPO, light scattering) to determine relative and absolute molecular weight distributions, chain growth and step growth mechanisms and kinetics, ionic polymerization, living polymerization, stereochemistry of polymers, free radical copolymerization (random, block, alternate and graft copolymers), kinetics and mechanisms of free radical copolymerization, polymerization conditions and polymer reactions, thermal, mechanical and solution properties of polymers, thermoplastics, thermosets and elastomers, conducting polymers, branched polymers (star, dendritic and hyperbranched polymers).

Course Outcomes: Polymers are integral part of our day to day life in this modern world. This course provides an understanding of basic polymer chemistry, mechanism of formation and applications of different thermoplastic and thermosetting polymers. Apart from this student can also learn the concept of molecular weight and analytical methods to isolate and purify polymers molecules. This course is very relevant in terms of academic as well as industrial importance.

Essential Readings:

CY 3402 PROPERTIES OF SOLIDS 3 Credits [3-0-0]


Course Outcomes: The students will learn various important properties of solids in detail. The students will had comprehensive knowledge about chemistry behind the materials and they can make correlation between the structure and outward properties of the solids.

Essential Reading:


Supplementary Reading:


**CY 3106**  
**PURIFICATION AND CHARACTERISATION TECHNIQUES FOR ORGANIC COMPOUNDS**  
4 Credits [3-1-0]

Academic Group: **Organic Chemistry**

Various methods of purification: Sublimation, Crystallisation, Distillation (Fractional distillation, Steam distillation, Differential Extraction, Chromatography (Adsorption chromatography, Partition chromatography), Paper chromatography, Thin-layer chromatography, column chromatography, gas-liquid chromatography, ion-exchange chromatography.

Estimation of elements, Determination of molecular weight.

Spectroscopic techniques of characterisation: **UV-Vis spectroscopy** (Basic principle, instrumentation, characteristic absorptions of organic compounds, **IR Spectroscopy** (Basic principle, instrumentation, modes of vibration, absorption trends, analysis of IR spectrum), **NMR Spectroscopy** (^1H NMR, Basic principle, chemical shift and shielding, instrumentation, chemical equivalence, magnetic equivalence, spin-spin coupling, NMR spectrum of simple organic compounds), **Mass-spectrometry** (Basic Principle, instrumentation, ionization methods, fragmentation, molecular ion peak, metastable peak, McLafferty rearrangement, nitrogen rule, Mass analysis of simple compounds). Comprehensive problems on structure elucidation of small organic molecules.

Course Outcomes: This course will help the students in understanding various techniques used for purification and characterization of mainly organic compounds (partly inorganic compounds too).

Essential Reading:


Supplementary Reading:


**CY 3702**  
**NATURAL PRODUCT ISOLATION LABORATORY**  
1 Credits [0-0-2]

Academic Group: **Organic Chemistry**

Co-ordinator:
Isolation of following compounds: Caffeine from Tea, Lycopene from Tomatoes, Piperine from pepper, Clove oil by distillation, eucalyptus oil from eucalyptus leaves.

Course Outcomes: This course gives basic training on extraction and characterization of organic compounds from natural resources.

Essential Reading:

Supplementary Reading:

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CY 3704 QUANTITATIVE ANALYSIS OF INORGANIC COMPOUNDS
1 Credits [0-0-2]

Academic Group: Inorganic Chemistry
Co-ordinator:

Quantitative analysis of inorganic compounds such as Ni^{2+} and Cu^{2+}. Estimation of Ca and Mg in a mixture by EDTA. Estimation of Ni as DMG complex by spectrometry.

Course Outcomes: The students will become familiar with various quantitative methods used for analysis of organic and inorganic compounds.

Essential Reading:

Supplementary Reading:

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CY 4101 STEREOCHEMISTRY AND REACTION MECHANISM
3 Credits [3-0-0]

Academic Group: Organic Chemistry
Co-ordinator:


Reaction Mechanism: Methods of determining reaction mechanisms, Prediction of Probable Products – Kinetic vs Thermodynamic Control, Hammond postulate, Curtin Hammett principle, Kinetic isotope effect, Baldwin rules for ring closure. Effect of structure
and medium on reactivity, Substituent Effects, Hammett Plots and Linear Free Energy Relationships, Other Linear Free Energy Relationship, Acid-Base Related Effects, Substitution Reactions: $S_N1$, $S_N2$, $S_{N1}'$, $S_{N2}'$, reactions, reactivity, solvent effect, nature of bases, effects of leaving groups. Neighboring Group participation, Nonclassical carbocations, Phase transfer catalysis. Ring expansion and ring Contraction reactions, Aromatic electrophilic substitution reaction, Aromatic nucleophilic substitution reaction, Addition Reactions: Addition to carbon-carbon multiple bonds, addition to carbon-hetero multiple bonds Elimination reactions: E2, E1 E1cB, regioselectivity and stereoselectivity of the double bond, Reactivity in elimination reactions, Pyrolytic eliminations. (Chugaev Elimination, Hoffmann degradation, cope reaction).

Course Outcomes: This course gives the understanding about the three dimensional arrangement of organic molecules and and their reactivity profile. This course also delivers the understanding how and which organic molecules react with each other to give a different product(s).

Essential Reading:

Supplementary Reading:
2. D. J. Hart, Organic Synthesis via Examination of Selected Natural Products.


**CY 4301 QUANTUM CHEMISTRY**  3 Credits [3-0-0]

Academic Group: **Physical and Computational Chemistry**

Co-ordinator:


**Course Outcomes:**
The course is designed to provide an overview of the quantum chemical description of atoms and molecules, their reactivity and chemical bonding. After completing this course the students are expected to understand quantum chemical principles and the necessary mathematical techniques. They should be able to explain the electronic structure of atoms and molecules. They should be able to apply the knowledge gained in this course to explain atomic and molecular spectra.

**Essential Reading:**

**Supplementary Reading:**

**CY 4103 SPECTROSCOPIC METHODS OF ANALYSIS**  3 Credits [3-0-0]

Academic Group: **Organic Chemistry**

Co-ordinator:

**Electromagnetic radiations:** Types of molecular energy and molecular spectroscopy

**Infrared Spectroscopy:** Basic theory, instrumentation and application to functional group determination. **UV-Visible Spectroscopy:** Basic concepts, instrumentation and applications; **Mass Spectrometry:** Principle, Instrumentation and applications, Fragmentation pattern of organic compounds, McLafferty rearrangement; **NMR Spectroscopy:** Basic principles, Chemical shift, Spin-Spin Coupling, Coupling Constant, NOE, $^{13}$C NMR, DEPT NMR, heteronuclear coupling, Pulse NMR spectroscopy and techniques, relaxation time and their importance, determination of relaxation times, Temperature dependent NMR and molecular dynamics, Elementary ideas on 2D NMR spectroscopy (COSY, NOESY, HMQC, HSQC, HMBC), Extension to other nuclei ($^{19}$F, $^{31}$P etc).

**Structure elucidation of Organic Compounds:** Use of spectroscopic techniques for structure determination and other applications.

**Optical rotatory dispersion and Circular dichroism:** Definition, deduction of absolute configuration, octant rule for ketones.
Course Outcomes: The students will able to understand the basic spectroscopic methods used for the analysis of organic compounds. Detailed discussions on principles, instrumentations and applications of these techniques will be carried out.

Essential Reading:

Supplementary Reading:

CY 4303 CHEMICAL APPLICATIONS OF GROUP THEORY 3 Credits [3-0-0]

Academic Group: Physical and Computational Chemistry

Co-ordinator:

Definitions and theorems of group theory: Groups, subgroups, classes, Molecular symmetry and symmetry groups: Elements of symmetry, operations, proper axes and rotation, product of symmetry operations, equivalent symmetry, point groups, Representation of groups: Matrices, vectors, great orthogonality theorem, character table, Group theory and quantum mechanics: Irreducible representation, direct product, nonzero matrix elements, Symmetry Adapted Linear Combination: Projection operators, their derivation and construction, Application in molecular spectroscopy: General cases of LCAO-MO π bonding, electronic excitations, selection rules, symmetry based selection rules, Transformation properties of atomic orbitals, examples in ABₙ type molecules, Ligand field theory, construction of energy level diagrams, molecular vibrations: symmetry of normal vibrations, selection rules of fundamental vibrations, application in Raman spectroscopy,

Course Outcomes: This course aims to develop the concept how symmetry considerations in molecules dictates chemical bonding as well as the way molecules interact with electromagnetic radiation i.e. molecular spectroscopy. The course relates quantum mechanical postulates with electronic structure of molecules by providing a mathematical interpretation in terms of group theory.

Essential Reading:
Supplementary Reading:

CY 4701 ORGANIC COMPOUND PREPARATION LABORATORY 2 Credits [0-0-3]

Academic Group: Organic Chemistry

Preparation of following compounds: p-nitrobenzoic acid from p-nitrotoluene (Oxidation), Benzhydrol from benzophenone (Reduction), selective reduction of p-nitroacetophenone (NaBH₄/MeOH), salicylaldehyde from phenol (Reimer-Tiemann Reaction), 2,5-dihydroxyacetophenone (Fries rearrangement), Quinoline (Skraup synthesis), 2-phenylindole (Fisher-indole synthesis), Indigo from o-nitrobenzaldehyde.

Course Outcomes: This course gives an understanding of basic organic Synthesis, preparation of derivatives. This will also enable the students to handle and expertise in characterization techniques.

Essential Reading:

**Supplementary Reading:**

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**CY 4703 PHYSICAL CHEMISTRY LABORATORY** 2 Credits [0-0-3]

Academic Group: Physical and Computational Chemistry

Co-ordinator:

Chemical Kinetics: Alkaline hydrolysis of ethylacetate; Kinetics of iodination of acetone by (i) Volumetry and (ii) Spectrophotometry; Polarimetric determination of concentration of unknown sugar solution and Study of kinetics of inversion of sucrose. Thermodynamic Properties of Solutions: Determination of the dimerisation constant of benzoic acid in benzene medium by partition method; Determination of equilibrium constant of the reversible reaction \( K + I_2 \leftrightarrow KI_3 \); Determination of Co-ordination number of copper in copper-amine complex by distribution method. Phase Equilibrium: Determination of critical solution temperature of two partially miscible liquids; Effect of electrolyte on the critical solution temperature of two partially miscible liquids; Phase diagram of two component simple eutectic system, Simultaneous estimation of Manganese and Chromium in a solution of \( K_2Cr_2O_7 \) and \( KMnO_4 \); Job’s continuous variation method to know the stoichiometry of metal complexes, Determination of indicator constant (\( pK_a \)) of an indicator.

**Course Outcomes:** These courses are intended to acquaint the students with the practice of experimental physical chemistry. To apply the principles of thermodynamics, kinetics, spectroscopy and various other topics presented in the physical chemistry courses, in some illustrative experiments.

**Essential Reading:**

**Supplementary Reading:**

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**CY 4102 REAGENTS AND REARRANGEMENTS IN ORGANIC SYNTHESIS** 3 Credits [3-0-0]

Academic Group: Organic Chemistry

**Reactive intermediates and name reactions:** Generation, structure, stability and reactions involving the intermediates: Carbocation (Pinacol-Pinacolone Rearrangement, Wagner-Meerwein Rearrangement, Demjanov reaction, Favorlosi Rearrangement, Fries Rearrangement, Benzil-Benzilic Acid Rearrangement), carbanion (Alkylation, Aldol condensation (asymmetric reaction), Ribbinson annulation, Claisen condensation, Dieckmann condensation Reaction, Perkin Reaction, Stobbe Condensation Reaction, Moritza-Baylis-Hilman reaction, Bamford-Steven, Shapiro reaction), Free radicals (Alllylic halogenations, acyloin condensation, McMurry coupling, Hunsdiecker reaction, Bouveault-Blanc reduction), carbonates (Wolff Rearrangement, Reimer-Tiemann), nitrenes (Hofmann, Beckmann, Curtius, Schmidt, Lossen Rearrangement), arenes, ylides (Wittig Reaction).

**Oxidizing reagents:** Chromium reagents, manganese reagents, Ruthenium tetroxide, TPAP, Lead tetraacetate, Osmium tetroxide, Hypervalent Iodine reagents [Dess-Martin periodinane (DMP), \( \text{o-iodoxy benzoic acid (IBX)} \)], Ceric ammonium nitrate, DDQ, Selenium dioxide, DMSO based oxidizing reagents, Aluminium alkoxides (Oppenauer Oxidation), peroxyacids.
Reducing reagents: Heterogeneous Catalytic hydrogenation; Homogeneous Catalytic hydrogenation (Wilkinson’s Catalyst), Dissolving metal reduction (Clemmesen Reduction Reaction, Birch Reduction); Reduction with hydride-transfer reagents (Aluminium alkoxides, Lithium aluminium hydride, sodium borohydride, DIBAL-H, Tinhydrides, Silanes, diimide, Borane and derivatives.

Course Outcomes: This course gives a detailed understanding of the reactivity and applications of important reagents used in organic synthesis. It provides the knowledge about principles and mechanism of different kinds of rearrangement in organic chemistry.

Essential Reading

Supplementary Reading

CY 4202 ADVANCED TOPICS IN INORGANIC CHEMISTRY 3 Credits [3-0-0]

Academic Group: Inorganic Chemistry
Co-ordinator:

Coordination Chemistry and Reaction Mechanism: Thermodynamic and kinetic stability, Substitution reactions-Inert and labile compounds, substitution reactions in square planar complexes (Trans effect), Substitution reaction and mechanism in octahedral complexes, factors affecting the rate of substitution, kinetics of dissociation, interchange and associative reactions, Oxidation-reduction reactions, inner and outer sphere reactions. M-L complex stability constant determination. Electron Transfer in metal complexes.

Electronic spectra – UV-Vis, selection rule, mechanism for breakdown of selection rule, absorption band width and shape, term symbol and splitting of terms in free atoms, energy level diagrams, nephelauxetic effect, Orgel and Tanabe-Sugano diagrams, calculation of Dq, B, C, Nephelauxetic ratio. Charge transfer spectra, Magnetic properties of complexes, Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD). Stability of unusual oxidation states. EPR, Mossbauer spectroscopy, electron spectroscopy, microscopic techniques.

Lanthanides: Extraction, separation, laser; Actinides: synthesis of trans-uranium elements and its uses, actinide metals- preparation and structures, general observations (comparisons with lanthanides).

Course Outcomes: The course is designed to provide overall understanding of spectral properties of coordination complexes and f-block elements. Especially, the students will able to learn the physical properties of lanthanides and actinides.

Essential Reading:
Supplementary Reading:

CY 4302 MOLECULAR SPECTROSCOPY  3 Credits [3-0-0]

Academic Group: Physical and Computational Chemistry

Co-ordinator:


Course outcomes:
This course is a useful tool to understand the fundamentals of various spectroscopic techniques. The systematic study through integrated problems makes students thorough and confident on utilization of spectroscopic techniques to characterize a molecule.

Essential reading:

Supplementary reading:

CY 4104 PERICYCLIC REACTIONS AND PHOTOCHEMISTRY  4 Credits [3-1-0]

Academic Group: Organic Chemistry

quinodimethanes, benzofurans. Photochemical and thermal [2+2]-cycloaddition reaction, Ketene cycloaddition, Alder ‘Ene Reaction’ Transition metal-catalyzed cycloadditions. 1,3-Dipolar cycloadditions application to heterocycle synthesis (Huisgen reaction, “Click” reaction). Cheletropic reactions. Sigmatropic reactions: Orbital description, [1,3], [1,5], [1,7], [2,3], [3,3] and [5,5] sigmatropic shifts, theory and reactions. Cope rearrangement, Oxy-cope rearrangement, Claisen rearrangement, Abnormal-claisen rearrangement, variants of Claisen rearrangement.


**Course Outcomes:** This course offers understanding how some organic molecules react with each other under thermal and photochemical conditions in a single step to give important molecules. Also, the students will have understanding on the reactivity of different reagents leading to organic transformations.

**Essential Reading:**

**Supplementary Reading:**

**CY 4402 SOLID STATE CHEMISTRY**

3 Credits [3-0-0]

**Academic Group:** Inorganic Chemistry

**Co-ordinator:**

Structural Principles: Crystalline and amorphous solids; crystal systems, types of close packing - hcp and ccp, packing efficiency, radius ratios; polyhedral description of solids; structure types -NaCl, ZnS, Na₂O, CdCl₂, wurtzite, nickel arsenide, CsCl, CdI₂, rutile and Cs₂O, perovskite ABO₃, K₂NiF₄, spinels. Synthetic Techniques: Solid state reaction, chemical precursor method, co-Precipitation, sol-gel, metathesis, self-propagating high temperature synthesis, ion exchange reactions, intercalation / deintercalation reactions; hydrothermal and template synthesis; High pressure synthesis, Methods of Single Crystal Growth: Solution growth; Melt Growth-Bridgeman, Czochralski, Kyropoulus, Verneuil; Chemical Vapour Transport; Fused Salt Electrolysis; Hydrothermal method; Flux Growth. Characterization methods: x-ray diffraction, electron and neutron diffraction; Thermal analysis: TGA, DTA, DSC. Electrical and Magnetic properties: Band theory of solids -metals and their properties; semiconductors - extrinsic and intrinsic, Hall effect; thermoelectric effects (Thomson, Peltier and Seebeck); insulators - dielectric, ferroelectric, pyroelectric and piezoelectric properties; ionic conductors. Superconductivity: Basics, discovery and high Tc materials. Magnetism: Dia, para, ferro, ferri, and antiferro magnetic types; soft and hard magnetic materials; selected magnetic materials such as spinels, garnets and perovskites, hexaferrites and lanthanide-transition metal compounds; magnetoresistance. Optical properties: Luminescence of d- and f- block ions; structural probes; up and down conversion materials.

**Course Outcomes:**

The students will be able to relate the structure-composition-property co-relations. This course will be able to provide the basic concepts and depth understanding of many physical properties of solids.
**Essential Reading:**

**Supplementary Reading:**

**CY 4304  STATISTICAL THERMODYNAMICS  3 Credits [3-0-0]**

Academic Group: **Physical and Computational Chemistry**  
Co-ordinator:

**Equilibrium Thermodynamics:** Thermodynamic Equilibrium state, brief overview of laws of thermodynamics, thermodynamic potentials, stability criteria, phase equilibria.  
**Ensembles in Statistical Mechanics:** Ensemble postulate and ergodicity, microcanonical, canonical and grand canonical ensembles, phase space, fluctuations.  
**Noninteracting particles:** Distribution laws, partition functions, thermodynamics quantities in terms of partition functions, quantum correlations, collective modes, fermions, bosons, photons, factorization of the molecular partition function.  
**Application to chemical systems (interacting particles):** Ideal gases; residual entropy, the liquid states; interparticle potentials, configurational partition functions, pair correlation function, neutron scattering experiments, virial equation, solutions; lattice model, ideal and non-ideal solutions, solutions of electrolytes; Debye-Huckel theory and its modifications, Computer simulations; ensemble averages, random numbers, Monte Carlo methods, Molecular dynamics, linear response theory, fluctuation dissipation theorem, time correlation functions, transport coefficients. Case studies: helix-coil transition in polypeptides etc.

**Course Outcomes:** The course aims to focus on the details of microscopic picture of thermodynamics. Student would be expected to develop strong understanding of the macroscopic phenomena from a microscopic or molecular point of view.

**Essential reading:**
2. Statistical Mechanics, Donald A. McQuarrie, University Science Books  

**Supplementary Readings:**

**CY 4306  BIOCHEMISTRY  3 Credits [3-0-0]**

Academic Group: **Physical and Computational Chemistry**  
Co-ordinator:

Basic cell biology: components of cells, cell organelle and their function, cell cycles and cell divisions, cell morphology, cell culture  
Enzymes: Enzymatic reactions, Types of enzymes and their functions, Enzyme kinetics, Michaelis-Menten kinetics, reaction order, competitive, uncompetitive, non-competitive and irreversible inhibition of enzymes. Regulatory enzymes and their mechanism.
Bioenergetics: thermodynamic considerations, phosphoryl group transfers and ATP, redox potentials, bioenergetic principles.

Biosignaling: molecular mechanism of signal transduction, gated ion channels, sensory transduction in vision, olfaction, oncogenesis, tumor suppressor genes and programmed cell death.

Metabolism: aerobic and anaerobic oxidations, glycolysis, gluconeogenesis, pentose phosphate pathway, Photosynthesis, Calvin’s cycle, Kreb’s cycle, cofactors, mitochondrial electron transport and oxidative phosphorylation.

Fatty acid catabolism, amino acid oxidation and production of urea.

DNA based information technologies: DNA cloning—the basics, from genes to genomes, from genomes to proteomes, concept of DNA microarray technology, genome alterations and new products of biotechnology, Genes and chromosomes: genetic recombination.

Course Outcomes: This course offers a thorough understanding of basic biochemical reaction and helps to make the foundation for applying knowledge of chemistry for research in biology and medicine.

Essential Reading:


Supplementary Reading:


**Course Outcomes:**

**COMP 1234** COMMUNICATION SYSTEMS 3 Credits [0-0-3]

Academic Group: Physical and Computational Chemistry

Co-ordinator:

Introduction: surface energy and the colloidal state, Stability: forces involved kinetic properties, Electrical property: Charged nature of colloids, concept of electrical double layer (no detailed mathematical derivation), qualitative approach, Stern theory, concept of zeta potential and factors affecting it, Electrokinetic phenomena: particle electrophoresis, gel electrophoresis, SDS PAGE, zone electrophoresis. Electroosmosis, streaming and sedimentation potential, Optical Characterization: optical microscopy, electronic microscopy, dark field microscopy, scattering of light by colloids, Rayleigh scattering vs Mie scattering (qualitative comparison), Surface tension, intermolecular forces at the interface, Phenomena at curved surfaces, Young-Laplace equation, derivation of Kelvin equation, implication of Kelvin equation: enhanced vapor pressure of liquid droplets, enhanced solubility of solids, Ostwald ripening, Adsorption and orientation at the interface: surface excess, Gibbs isotherm (qualitative treatment and significance). Surfactants: property, classification and application, Micelles: structural types, critical micelle concentration (cmc), Kraft temperature, factors affecting cmc, critical packing parameter, characterization techniques of micelles, Definition, role of surfactant in emulsion, thermodynamic stability of microemulsion, industrial application of emulsion and microemulsion, Three component systems (oil-water-surfactant), interpretation of ternary diagrams, Winsor systems (type I, II and III), Adsorption: physisorption, chemisorptions and thermodynamic consideration and reversibility, Langmuir's theory: adsorption isotherm, Types of isotherm, drawback's of Langmuir's theory, BET theory, basic consideration, general form of BET equation, application of BET equation, measurement of surface area, adsorption in porous solids (type IV isotherm, hysteresis and theories explaining the hysteresis), Surface plasmons: definition, qualitative picture, surface plasmon resonance, absorption bands and significance, variation of Surface Plasmon absorption maxima in gold colloids with size, Effect of interaction between solid surface and high energy electron beam: generation of primary, secondary, Auger electrons and X-rays (characteristic: EDS and non-characteristic: Bremsstrahlung), Atomic force microscopy: basic principle (qualitative idea) and application.

**Course Outcomes:**
As colloidal state of matter and interface between two phases are integral part of physical chemistry as well as material science, this course aims to develop fundamental concepts on molecular forces, surface tension and how colloidal state is exploited in industrial applications. The same course would also provide a conceptual background on basic properties of colloidal nanomaterials.

**Essential Reading:**

**Supplementary Reading:**

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**CY 4106 SUPRAMOLECULAR AND MACROMOLECULAR CHEMISTRY**

3 Credits [3-0-0]

**Academic Group:** Inorganic Chemistry

**Co-ordinator:**

From molecular to supramolecular chemistry: factors leading to strong binding, hydrogen bonding and stacking interactions. Molecular models of biological receptors, biomimetic chemistry, design, synthesis and binding studies of synthetic receptors. Metal guided self assembly reactions, molecular knot with double helical complexes of Cu(I). Self assembly of polynuclear metal complexes. New molecular receptors: crown ethers, siderophores, cyclophanes, cyclodextrin and their application in specific recognition processes. Anion coordination chemistry and recognition. Supramolecular reactivity and catalysis, supramolecular devices. Introduction to polymer chemistry: Introductory concepts, definition, common system chemistry and classification of polymers, synthetic and natural polymers, types of polymerization, addition, condensation, co-ordination and ring opening polymerization, Preparation, properties and uses of some important thermoplastic (i.e. PE, PVC, Teflon, PS, PMMA) and thermosetting resins (i.e. Phenolic resin, Amino resin and Epoxy resin), natural and synthetic rubbers, Fibers (i.e. Nylons, PAN, Polyurethanes). Polymer Characterization: molecular weight studies and molecular weight distribution, poly dispersive index, determination of molecular weight of polymers. Polymer behavior, crystalline and thermal behavior. Glass transition temperature, factor influencing glass transition. Polymerization techniques: bulk, solution, emulsion, and suspension polymerization, polymer colloids and polymer solution. Thermodynamics aspect of Polymerization, Stereo Chemistry and mechanism of polymerization: free radical, cationic and anionic polymerization. Relevant aspects of physical properties of polymer systems, rheological properties, polymer processing, processing techniques i.e. molding, casting, extrusion and, calendaring techniques. Polymer degradation and stabilization, biological degradation of polymers. Polymers & environments, environmental pollution by polymers. From molecular to supramolecular chemistry: factors leading to strong binding, hydrogen bonding and stacking interactions. Metal guided self-assembly reactions, molecular knot with double helical complexes of Cu(I), Self-assembly of polynuclear metal complexes, Molecular receptors: crown ethers, siderophores, cyclophanes, cycloexetrin and their application in specific recognition processes. Supramolecular reactivity and catalysis, supramolecular devices.

**Course outcomes:**

In this modern world, macromolecules are integral part of our day to day life style. This course includes polymer and supramolecular chemistry, which is helpful in understanding the fundamentals of macromolecular science especially the structure, physical and chemical properties, formation and applications of macromolecular materials in various fields such as medicine, food, paints & coating technology, packaging, membrane and separation science, protective clothing and so on. Apart from this, students also learn the mechanism of the formation of various synthetic polymers and bio-polymers.
Essential Reading


Supplementary Reading


CY 4702  INORGANIC CHEMISTRY LABORATORY  2 Credits [0-0-3]

Academic Group: Inorganic Chemistry
Co-ordinator:

Semimicro qualitative analysis (anions are excluded) and quantitative estimations (Polarography, spectrophotometry, pH metry and Flame photometry). Synthesis of inorganic compounds (air-sensitive, moisture-sensitive etc.). Characterization and property measurements of inorganic (especially coordination) compounds. Exposure to various spectroscopic characterization techniques.

Course Outcomes: The students will have hands-on experience on techniques used for quantitative estimations of inorganic compounds. Also, they will become familiar with the techniques to handle various air-sensitive compounds.

Essential Reading:
1. In-house laboratory manual and relevant literatures.

Supplementary Reading:

CY 4704  MATHEMATICAL AND COMPUTATIONAL METHODS IN CHEMISTRY  2 Credits [1-0-3]

Academic Group: Physical and Computational Chemistry
Co-ordinator: Prof. M. Jana

Mathematics for chemistry: Fundamental theorem of calculus, series and limits, Euler's formula, ODEs, Fourier transforms, operators, functions of several variables, matrix eigenvalue problem, vector space, probability, correlations. Basic understanding of computational chemistry, use of Linux operating system. Numerical computing using scientific language: Elements of Fortran programming, constants, variables and operators, control statements, I/O operations, functions, loops, DATA statements, arrays, sub programs, DATA files. Roots of equations, truncation and round off errors, interpolation, differentiation and integration, linear equations, matrix operations, regression analysis and least square fit. Applications to chemistry: statistical thermodynamics, chemical kinetics, calculation of energies associated to molecular systems, curve fitting. Use of software packages: visualization and plotting, semi-empirical methods.

Course Outcomes:
This course will explain direct use of numerical methods in chemistry and compare those results with the experimental data. The computer experiments will demonstrate a working knowledge of a range of additional computational chemistry packages. Students will be able to apply this knowledge to tackle chemical problems.

Essential Readings:

Supplementary Readings:

CY 5101 METHODS IN ORGANIC SYNTHESIS 3 Credits [3-0-0]

Academic Group: Organic Chemistry

C-C bond forming reactions: Main Group Chemistry – Organometallic reagents in Organic synthesis: Principle, preparations, properties and applications of the following in organic synthesis with mechanistic details: Organomagnesium (Grignard reaction), Organozinc (Reformatsky Reaction), Organolithium, Organoaluminium, Organosilicon, Organocerium, Organoboranes (Hydroboration of alkenes, Allyl boranes, CBS reaction), Organocadmium, Organomercury, Organosilicon, Organotin (Reduction with tri n-Butyltinhydride), Organoaluminium compounds, Transition-metal Chemistry: Organotitanium, Organochromium, Organocopper, OrganocopperOrganopalladium compounds, Metal carbenes (Fischer Carbene, Schrock carbene and their application).

Protecting groups: Protection of alcohols, 1,2-diols, 1,3-diols, thiols, carboxylic acids, carbonyl compounds, amines. Protection of carbon-carbon multiple bonds. Illustration of protection and deprotection in synthesis.


Organocatalysis: Introduction to organo-catalyzed reactions, Classifications (HOMO, LUMO, SOMO catalysis), Enamine, Imminium, H-bonding catalysis and asymmetric organocatalysis (Michael, aldol, Mannich etc).

Course Outcomes:
This course enables an exposure to the basic fundamentals of organic reactions. The students will have a better understanding on various synthetic methodology employed in organic Synthesis.

Essential Reading:

Supplementary Reading:
Introduction:

- Metal ions essential for biological functions.
- Basic coordination chemistry in biology: biological ligands for metal ions, Metal ions specificity.

Ion-transport and Signal transduction:

- Ion (Na⁺ and K⁺) transport: Ion Channels & Pump, Ionophore
- Ca²⁺: Cell Signalling (Calmodulin) and Heart Pumping (Troponin C)
- Mg²⁺: ATP Hydrolysis

O₂ storage and transport:

- Myoglobin/Hemoglobin and Hemocyanin (Cu)/Hemerythrin

O₂ activation and toxicity/detoxification:

- Cytochrome P450, Peroxidase, Catalase, SOD

Fe transport, storage and acquisition: Transferrin, Ferritin and Siderophore

Electron Transfer: Cytochromes, Fe-S Cluster, and Plastocyanin (Cu); Marcus Theory

ATP Synthesis: Photosynthesis, and Respiration: Cytochrome C Oxidase (Fe & Cu)

Nitrogen Fixation: Nitrogenase (Fe & Mo)

Zn²⁺ (Lewis Acidity): Carbonic Anhydrase, Carboxy Peptidases, ADH and Zinc Finger protein

Group Transfer: Vitamin B12 (Co)

Metals in Health:

- Metal toxicity: Mercury and Arsenic; Metals in Diagnosis: Gd, Fe; Metals in Treatments: Pt, Au

Methods in Bio-inorganic Chemistry:

- Resonance Raman, Mössbauer and EPR Spectroscopy, Cyclic Voltammetry, Site-Directed Mutagenesis

Course Outcome:

The course is designed to provide an overview of the biological needs and the behaviors of Inorganic Elements linked to several metalloproteins and enzymes. The importance of metal ions in the active-site structure and function of metallo-proteins and enzymes will be illustrated. After completing this course the students are expected to understand the importance of bio-active elements in our daily life. They should be able to apply the knowledge gained in this course to explain several problems associated with bio-inorganic chemistry research.

Essential Reading:


Supplementary Reading:

2. K. H. Reddy, Bioinorganic Chemistry, New age International Publisher, 2005

Course Outcomes:

This course will provide basic understanding on structure, bonding, preparation and application of organometallic compounds. The importance of organometallic catalysis will also be highlighted and provide thorough understanding of various inorganic reaction steps and the mechanism involved in those reactions.

Essential Reading:

Supplementary Reading:


**Course Outcomes:** The course highlight the concept of different chemical and photochemical reactions happens in the environment and their effect on the living organism and materials and how these effects can be mitigated. Moreover, it clears the basic concept related to different segment of environment. It gives many research ideas to pursue in future.

**Essential Reading:**

**Supplementary Reading:**

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**CY 5103 HETEROCYCLES AND NATURAL PRODUCTS** 3 Credits [3-0-0]

**Academic Group: Organic Chemistry**

**Heterocycles:** Nomenclature of Heterocycles with more than one heteroatom, Structure and uses of heterocyclic compounds, Synthesis and Reactivity of indoles, azines, purines, pyrimidines, pteridines, azeridine, oxirane, thirane, oxaziridine, azetidine, azetidinone, oxetane, oxetanone, thietane, azoles, fused heterocycles containing oxygen and sulfur hetero atoms (benzofurans, benzothiophene, benzopyrones). Heterocycles in natural products, medicines and materials.

**Alkaloids:** Occurrence, Functions of Alkaloids, Classification, Isolation, Properties, and synthesis:quinine (Coniine), Morphine.

**Terpenoids:** Classification, Structural features of Terpenoids, specific importance to reactions of double bonds with Chromic acid, Ozone, catalytic hydrogenation, Tilden reagent, Hydroxylating agents etc. Monoterpenoids, diterpenoids, Triterpenoids. Detailed discussions on Myrcene, Menthol. Geometrical considerations of Neral & Geranial, Menthol. Biosynthesis of natural products.

**Steroids:** General biosynthesis studies of steroids, structure of cholesterol and ergosterol (synthesis). Stereochemistry of steroids, chemistry of bile acids.

**Hormones:** Definition, classification, synthesis of adrenaline, thyroxine, Structural formulae of estradiol, progesterone and testosterone and their importance. Peptide hormones-oxytocin and insulin – action, uses and side effects.

**Uric acid:** Structure and synthesis of Uric acid, conversion of uric acid to purine and caffeine, Synthesis of guanine and theobomine.

**Course Outcomes:** Heterocyclic compounds are integrated part of various medicinally important natural products. This course emphasizes structures of important classes of heterocyclic organic compounds, classification between electron rich and electron deficient heterocycles and their reactivities. It provides the knowledge about the bio-availability, isolation, stereochemistry and synthesis of some important natural products. It gives adequate knowledge regarding the synthesis, application and biological activity of various important classes of heterocyclic compounds and natural products.

**Essential Reading**

**Supplementary Reading**

**CY 5205 ANALYTICAL CHEMISTRY**

3 Credits [3-0-0]

Academic Group: Environment and Materials Chemistry

Co-ordinator:


Electroanalytical Techniques: Basic principles, instrumentation and analytical application pH – metry, potentiometry, conductometry, coulometry, polarography, voltammetry, Amperometry and ion selective electrodes.

Thermal method of analysis, Thermogravimetry [TG], differential thermal analysis [DTA], differential Scanning calorimetric [DCS], Thermometric titrations, Basic principle, Instrumentation and analytical application.

Atomic Spectroscopic Techniques: Atomic absorption (flame, graphite furnace, hydride generation and cold vapour) and atomic emission (flame, plasma, spark and arc) spectroscopy.

Radioanalytical Techniques: Neutron Activation analysis, isotope dilution analysis, radiometric titrations.

All the above methods will be focused for: Analysis of Minerals and Ores; Analysis of metals and alloys; Analysis of food and drug.

**Essential Reading:**


**Supplementary Reading**

1. Instrumental Methods of Analysis 5th editions 2009 , G.W. Ewing,
Co-ordinator:

Synthesis of oxides, sulfides, solid solutions, nanomaterials, as well as intercalation compounds using various synthetic methods such as solid state reaction, combustion, sol-gel, coprecipitation, hydrothermal, intercalation/deintercalation and organometallic precursor routes.
Characterization of the synthesized materials for determination of their structure, composition, morphology and physicochemical properties using XRD, IR, SEM, PPMS and temperature programmed method.

**Course Outcomes:**
The course is intended to provide a basic understanding about the synthetic methodology adopted for synthesis and characterization of inorganic materials. After completion of this course the students will be able to gain knowledge on structure-composition-property correlation of inorganic materials.

**Essential Reading:**
1. In house laboratory manuals.
2. A. R. West, Solid state chemistry and its applications, Wiley Student addition (John Wiley & Sons), 1988

**Supplementary Reading:**

**CY 5703  ENVIRONMENTAL CHEMISTRY LABORATORY  2 Credits [0-0-3]**

Academic Group: Environment and Materials Chemistry

Co-ordinator:

Determination of dissolved oxygen in water, Determination of Chemical Oxygen Demand (COD), Determination of Biological Oxygen Demand (BOD), Percentage of available chlorine in bleaching powder, Measurement of chloride, sulphate and salinity of water samples by simple titration method. (AgNO₃ and potassium chromate), Estimation of total alkalinity of water samples (CO₃²⁻, HCO₃⁻) using double titration method, Measurement of dissolved CO₂, Determination of iron, Magnesium, Calcium in water sample by titration methods, Estimation of SPM, CO₂ and SOₓ in air samples, Determination of Total Hardness and Temporary Hardness by EDTA titration, Determination of free chlorine in water sample, Determination of TDS, TSS, Acidity and Alkalinity of waste water sample. Estimation of halides in water samples by potentiometric titration, Determination of pH, salinity, and conductivity of water samples, Estimation of Co²⁺ and Ni²⁺ by colorimetry/ spectrophotometry, Estimation of sulphates and TDS by turbidometry, Estimation of alkali metals (Na⁺, K⁺) in various samples by flame-photometry,

**Course Outcomes:**
The course highlights the concept of different chemical reactions happens in the environment and how they can be measured by laboratory methods.

**Suggested Reading:**

**Supplementary Reading:**
Academic Group: **Physical and Computational Chemistry**

Co-ordinator:

Theory, computation and modelling: definition of terms, computable quantities, cost and efficiency. **Computational quantum mechanics (QM):** electronic structure methods; semi empirical methods, semi empirical implementations of molecular Orbital theory, ab-initio implementation of Hartree-Fock molecular orbital theory, basis sets, electron correlation methods; configuration interaction, Møller-Plesset perturbation theory, coupled-cluster theory, Density functional theory; Kohn-Sham Theory, density approximations, exchange correlation functional, applications. **Molecular mechanics (MM):** fundamental assumptions, potential energy functional forms, force-field energies and thermodynamics, geometry optimization, force-field and docking. **Molecular simulation:** phase space, and trajectories, Molecular Dynamics and Monte Carlo methods, properties as ensembles and time averages of trajectories, force-field performance in simulations. **Hybrid QM/MM:** models and applications. **Solvation:** implicit and explicit solvent models and applications. Case studies: gauche-butane interactions of 1,3-butadiene, effect of basis sets on total energy of some small organic molecules etc.

**Essential Readings:**


**Supplementary Readings:**


**Course Outcomes:** The course aims to discuss the use of sets of theories and techniques for investigating chemical problems on computer and interprets the results with the experimental data. It would help students to understand the strengths and limitations of each technique. This would help students to link between theory and experiments. The course further demonstrates a working knowledge of a range of computational chemistry packages.
After the end of this course, students will be able to have in-depth understanding of a new hot topic on nanoscience and nanotechnology. They will gain detailed information about various synthesis protocols, characterization tools and industrial applications of nanomaterials.

**Essential Reading:**

**Supplementary readings:**

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**CY 5402 CHEMISTRY OF INDUSTRIAL MATERIALS**

**3 Credits [3-0-0]**

**Academic Group:** Environment and Materials Chemistry

**Co-ordinator:**


**Oils and fats:** Analysis of oils, Industrial application of oil. Soaps and syndets, cleansing mechanism of soaps.

**Protective Coatings:** Metallic coatings, Organic coatings, paint and varinshes

**Cement:** Types of cement, composition, manufacturing process, setting of cement.

**Glass:** Types, composition, manufacture, physical and chemical properties, applications.

**Corrosion:** various types of corrosion relevant to chemical industry ,preventive methods.

**Cosmetics and Perfumes:** preparation and uses of some representative products.

**Essential oils**: importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, phenyl ethyl alcohol, Jasnone, Civetone, Muscone.

**Pesticides:** benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion ); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

**Fermentation Industries:** Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii) Pencillin

**Insecticides:** Fungicides and Herbicides: Classification, synthetic organic insecticides and fungicides and their importance.

**Wood protectants:** Creosote oil, pental chloraphenols.

**Course Outcomes:** This course highlights basic fundamental of some industrial material suitable to undergraduate student of all branches. This course introduces the concept of industrial process.

**Essential Reading:**

**Supplementary Reading:**

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**CY 5102 MEDICINAL CHEMISTRY**

**3 Credits [3-0-0]**
Introduction to medicinal chemistry: Introduction to medicinal chemistry concepts, Biomolecules as drug targets, Proteins and enzymes, Drug receptors, Genetic components as targets, working principle, transport and metabolism of drugs, Prodrugs and drug delivery systems, Drug design and QSAR, Drug discovery and development, Combinatorial chemistry, Structure-activity relationships, Specific drug families.

Anteoplastic agents: Cancer chemotherapy, role of alkylating agents and antimitabolites in treatment of cancer, anti-metabolites, carcinolytic antibiotics, mitotic inhibitors

Antibiotics: Constitution and synthesis of penicillins, chloramphenicol, tetracyclic and streptomycin

Antimalerials: Synthesis and properties of 8-amino-quinolone derivatives-pamaquine,primapune, pentaquinar, isopentaquine, 4-aminoquinolone derivatives-santoquine, camaquine, acidine derivatives-mepracrine, azacrin.


Course outcome
Although medicinal chemistry spans many disciplines, this course is designed to cover mainly the chemical aspect of drugs. Students will learn; i) The chemistry behind the development and activity of drugs, ii) How drugs interact with biological targets, iii) The role of medicinal chemists and chemistry in drug design.

Essential Reading

Supplementary reading:

MINOR COURSES

| CY 3111 | BASIC ORGANIC CHEMISTRY | 3 Credits [2-1-0] |

Introduction to organic compounds: alkanes, alkenes, alkynes, aromatic hydrocarbons (aromaticity, resonance energy), alcohols, organic halogen compounds, carbonyl compounds, carboxylic acids and derivatives (acid anhydrides, amides, acid halides, esters), nitro compounds, amines: Synthesis and reactions.

Heterocyclic compounds: Classification, Synthesis and reactions of furan, thiophene, pyrrole, pyridine, indole, quinoline, isoquinoline.

Organic reaction mechanisms & reactive intermediates: Carbocations, carbanions and free radicals (Generation, stability and reactions), substitution (S_N1, S_N2, S_Ni, neighbouring group participation, factor affecting SN reaction), elimination (E1,E2, E1CB) and addition reactions (C-C double bond).
**Stereochemistry:** Configuration and conformation, Geometrical isomerism, Optical isomerism, Enantiomers, Diastereomers, projection formulae, interconversion of projection formulas, D-L and R-S nomenclature (CIP rules), Erythro and threo nomenclature, dl- and meso compounds, Atropisomerism, Stereospecific and stereoselective reactions, Conformations vs reactivity of cycloalkanes.

**Oxidation and Reduction reactions:** Reagents used and functional group transformations based on oxidation and reduction reactions.

**Course Outcomes:** At the beginning the students will be introduced to simple organic compounds and their reactivity. Gradually the types, intermediates and outcome of organic reactions will be taught ending with two main reaction types (oxidation and reduction). Overall the course is designed for an introduction to organic chemistry.

**Essential Reading:**

**Supplementary Reading:**

**Atomic Structure:** de-Broglie matter waves, Uncertainty principle, Schrodinger wave equation, quantum numbers and its significance, Radial and angular wave functions, Radial and angular distribution curves, shape of s, p, d orbitals, Angular and radial nodes, sign of orbitals. Pauli’s exclusion principle, Hund’s rule of maximum multiplicity, Aufbau’s principle and its limitations, Variation of orbital energy with atomic number. **Chemical Bonding:** Ionic bond: types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Structure of NaCl, CsCl, ZnS, TiO₂, CdI₂. Expression for lattice energy. Born equation, polarizability, Fajan’s rule, and its applications. Covalent bonds: Lewis theory, Resonance, VBT, quantum mechanical approach to hybridization, directional characteristics, deduction of geometry by VSEPR method, Bent’s Rule, Qualitative treatment of MO theory applied to homo (N₂ vs O₂) and hetero (HF, CO, NO) diatomic molecules. **Coordination Chemistry:** Ligands, coordination numbers, coordination sphere, Nomenclature, Werner’s theory, EAN, Chelates, isomerism in coordination compounds, Valence Bond theory, Crystal Field Theory, octahedral, tetrahedral and square planner complexes, calculation of CFSE in octahedral and tetrahedral geometry. Application of CFT: Electronic (Color) and Magnetic properties of co-ordination compounds.

**Course Outcomes:** The students can apply the fundamental principles of measurement, matter, atomic theory, chemical periodicity, chemical bonding, general chemical reactivity and solution chemistry to subsequent courses in science, engineering, technology, allied sciences and various other related disciplines that depend upon these principles for successful comprehension.

**Essential readings:**

**Supplementary readings:**

Chemical Kinetics: Parallel, opposing and consecutive reactions; Analysing mechanisms using the steady-state approximation, Chain reactions (hydrogen-bromine reaction); Unimolecular reactions (Lindemann-Hinshelwood approach); Enzyme catalysis (Michaelis-Menten Mechanism).

Basic Concepts of Quantum Chemistry: Uncertainty principle; The Schrodinger wave equation for the hydrogen atom; physical meaning of a wave function, radial wave functions and probability densities, quantum numbers, wave functions and orbital shapes.

Molecular spectroscopy: Spectral regions and molecular motions, elementary concepts of rotational (diatomic rigid rotor, selection rules) spectroscopy, molecular vibrations (qualitative treatment of simple harmonic and anharmonic oscillator, selection rules), fundamental modes of vibration (examples of H$_2$O and CO$_2$), electronic spectra (vibrionic levels, absorption and emission), Beer-Lambert law, application in simple organic molecules.

Course Outcomes: This course would be able to introduce basic principles of physical chemistry to the undergraduate students. Students are expected to develop an analytical aptitude towards fundamentals of physical chemistry.

Essential readings:
1. P.W. Atkins and Julio de Paula, Atkin’s Physical Chemistry, Oxford University Press, 2010

Supplementary readings:
1. David W. Ball, Physical Chemistry, Cengage Learning, 2002

Academic Group: Inorganic/Organic Chemistry

Co-ordinator:

Identify the presence of each of the following anions: SO$_4^{2-}$, CO$_3^{2-}$, NO$_2^-$, Cl$, Br^-$, I$, and NO$_3^-$, using qualitative analysis. Qualitative tests on 3d-metal ions (Fe, Co, Ni, Cu). Identify the cations and anions in an unknown sample of ionic salts. Detection of elements (C,H,N,S, Halogen) in organic Compounds. Detection of functional groups: amine, amide, alcohol, phenol, nitro, carboxylic acid, aldehyde, ketone, unsaturation etc.

Course Outcomes: The students will become familiar with broad spectrum of practical skills in identifying the anions and transition metal cations, synthesis and characterization of compound as well as nanoparticles, and also connect with the basics knowledge and theory taught in theory classes. This course will also enable the students a comprehensive understanding of the basic laboratory techniques like chromatography and purification, etc.

Essential Reading
Supplementary Reading


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**CY 4412 ORGANIC AND POLYMER CHEMISTRY**

3 Credits [2-1-0]

Academic Group: **Organic Chemistry**

**Organometallic compounds**: Definition with examples, Preparation and synthetic applications of Organomagnesium reagent, organolithium compounds, Organozinc compounds, organocupper compounds, selected Name reactions (Grignard Reaction, Reformatsky Reaction and Gillman reaction) and their application in organic Synthesis.

**Carbohydrates**: Classification, Monosaccharides, erythro abd threo diasteromers, epimers, cyclic structures of monosaccharides, mutarotation, reactions of monosaccharides, reducing and non-reducing sugars.

**Amino acids**: Classification and nomenclature, configuration, acid-base properties, isoelectric point, synthesis and chemical properties of α-amino acids. **Peptides**: peptide bond, biologically important peptides. **Proteins**: Classification (Primary, Secondary, Tertiary, Quaternary- definition, examples) Forces that stabilize structure of proteins: H-bonds, hydrophobic interaction, electrostatic attraction, Van der Waal's interaction, dipole-dipole interaction.

**Nucleic Acids**: Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding, structure of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), double helix model of DNA and forces responsible for holding it. Chemical synthesis of mono and tri nucleosides. Chemical Properties: Hydrolysis (acid, alkali), enzymatic hydrolysis of DNA. General structure and types of RNA (tRNA, mRNA, rRNA).

**Natural Products**: Terpenoids (Citral), alkaloids (Nicotine), steroids (Cholesterol), Hormones (Adrenaline), Uric acid.

**Common drugs and vitamins**: Sulpha drugs, Antimicrobial, Analgesic-anti-inflammatory, Cardiovascular agent, Antihistamines, Antilaprosy and Vitamins.

Polymers: Introduction and applications of polymers, molecular weight distributions, various experimental methods (GPC/SEC, solution viscosity, VPO, light scattering) to determine relative and absolute molecular weight distributions, chain growth and step growth mechanisms and kinetics, ionic polymerization, living polymerization, stereochemistry of polymers, free radical copolymerization (random, block, alternate and graft copolymers)

**Course Outcomes**: The course would enable the students to learn about bioactive molecules starting from small amino-acids and carbohydrates to complex terpenoids, drugs and vitamins. Preliminary study of their structures, synthetic preparations are part of this course. Towards the end of the course the students would learn how the reactivity of organic compounds can be used to achieve the ultimate target, i.e. synthesis of the bioactive natural products. Also, introductory course on polymer materials will be discussed.

**Essential readings:**


**Supplementary readings:**

**CY 4214 INORGANIC AND MATERIALS CHEMISTRY**

3 Credits [2-1-0]

**s and p-Block elements:** Alkali, alkaline-earth metals, Boron family, Carbon family, Nitrogen family, Oxygen family and Halogen family. **d-Block elements** (Transition element): electronic configuration and comparative study of ionic radii, ionization potential, oxidation state, redox potential. **f-block elements:** spectra and magnetic properties, redox chemistry. **Nuclear chemistry:** Nuclear reactions, fission, fusion, Neutron activation analysis, isotope dilution analysis, Radiometric titrations, nuclear fuel reprocessing. Introduction to Materials Chemistry, Materials structure, Materials synthesis, Materials characterization, some important properties of materials.

**Course Outcomes:** The course is designed to provide overall understanding of main group, transition and f-block elements. Also, An introductory undergraduate level course to materials chemistry for students interested in the nature, preparation, characterization, and properties of crystalline inorganic solids in bulk, thin film, and nanoscale form.

**Essential Reading:**

**Supplementary Reading:**

**CY 4316 PHYSICAL AND COMPUTATIONAL CHEMISTRY**

3 Credits [2-1-0]

**Solid state chemistry:** arrangements of atoms in 3D, close packing vs simple packing of spheres, introduction of Miller indices (planes and directions) in cubic and hexagonal systems, crystal parameters and seven crystal systems, Bravais lattices (14 types), voids (tetrahedral, octahedral) in hexagonal and cubic systems, radius ratio rules, elementary concepts of X-ray diffractions, Bragg's equation, interplaner spacings, powder X-ray diffraction patterns by Debye-Scherrer method, difference between powder and single crystal diffraction patterns.

**Colloids:** colloidal state, kinetic stability, electrical double layer, concept of electrokinetic potential and applications, optical properties of colloids (scattering).

**Liquid surface:** surface tension and interfacial tension, phenomena at curved surfaces (Kelvin equation and its significance), capillary rise, bubbles and sessile drops, contact angles and wetting, concept of surfactants, micelles and self assembly, liquid crystals, emulsion and micro emulsion.

Surface analysis: elementary concepts of interaction of electrons with surface (secondary electrons, Auger effect, photoelectron spectroscopy, low energy electron diffraction), atomic force microscopy (introductory concept).

Course Outcomes: The course aims to focus on the details of advanced physical chemistry courses such as microscopic picture of thermodynamics. Student would be expected to develop strong understanding of the macroscopic phenomena from a microscopic point of view. The course aims to discuss the use of sets of theories and techniques for investigating chemical problems on computer and interprets the results with the experimental data.

Essential readings:

Supplementary readings:

Academic Group: Physical and Computational Chemistry

Co-ordinator:

Accuracy, precession, errors (systematic and random), estimation of errors.
1. Determination of Order for the Persulphate-Iodide Reaction
2. Determination of the rate constant of hydrolysis of an ester in aqueous acidic medium.
3. Conductometric titration of a mixture of strong and weak acid with a strong base
4. pH metric titration of a mixture of strong and weak acid with a strong base
5. Study of the distribution equilibrium of iodine in water/tolune.
6. Adsorption characterstics of acetic acid on charcoal
7. Verification of Beer-Lambert law.

Mathematics for chemistry: Fundamental theorem of calculus, series and limits, Euler’s formula, ODEs, Fourier transforms, operators, functions of several variables, matrix eigenvalue problem, vector space, probability, correlations. Basic understanding of computational chemistry, use of Linux operating system.

Course Outcomes: These experiments are intended to acquain the students with the practice of experimental physical chemistry. This course will also explain direct use of numerical methods in chemistry and compare those results with the experimental data. The computer experiments will demonstrate a working knowledge of a range of additional computational chemistry packages. Students will be able to apply this knowledge to tackle chemical problems.

Essential Readings:


**Supplementary Readings:**

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**DEPARTMENT OF LIFE SCIENCE**

**LS1001**  
**Biology**  
**2 Credits (2-0-0)**

**Pre-requisites:**
Nil

**Course Outcomes**
Upon completion of this course,
- Students will be able to differentiate the structure and function of prokaryotic and eukaryotic cells.
- Students will be able to explain the properties and functions of different biomolecules.
- Students will be able to understand the basic concepts in disease biology.


**Essential Reading**

**Supplementary Reading**

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**LS2101**  
**BASIC BIOCHEMISTRY**  
**3 Credits (3-0-0)**

**Prerequisites:**
LS1001 Biology

**Course Outcomes**
After completing this course,
- Students will be able to define “Biochemistry” and explain about four classes of biomolecules necessary for a complete life.

**Essential Reading**

**Supplementary Reading**

**LS2601 BASIC MICROBIOLOGY**
3 Credits (3-0-0)

**Prerequisites:**
LS1001 Biology

**Course Outcomes**
Upon completing this course,
- Students will acquire knowledge about microorganisms and their growth pattern.
- Students will list out names of microorganisms.
- Students will learn about the nutritional pattern of microorganisms.

Introduction to microbiology, Discovery of the microbial world, Classification of bacteria and virus, Ultrastructure of prokaryotes and eukaryotes, Cultivation of bacteria – Culture characteristics and Growth pattern, Nutritional and Physical Requirements, Types of media, Isolation, Maintenance and Preservation of the pure cultures, Batch and Continuous cultures, Diauxic and Synchronous growth, Enumeration techniques, Mathematical concepts in microbial growth, Lytic and lysogenic life cycles of bacteriophages. Microbial genetics.

**Essential Reading**

**Supplementary Reading**

**LS2401 CELL AND MOLECULAR BIOLOGY**
3 Credits (3-0-0)

**Prerequisites:**
LS1001 Biology

**Course Outcomes**
At the end of the course,

- Students will be able to differentiate various cellular structures.
- Students will be able to discuss functions of cellular organelles.
- Students will acquire knowledge about cell cycle, cellular trafficking and chromosomes.


**Essential Reading**

**Supplementary Reading**

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**LS2402 ANIMAL SCIENCE 3 Credits (3-0-0)**

**Prerequisites:**
LS1001 Biology

**Course Outcomes**
By the end of this course,

- Students will be able to understand about the taxonomy.
- Students will be able to tell the characteristics of different phyla of animals.
- Students will be able to describe the diversity of the animal kingdom.


**Essential Reading**

**Supplementary Reading**

**LS2403  PLANT SCIENCE  3 Credits (3-0-0)**

**Prerequisites:**
LS1001 Biology

**Course Outcomes**
Upon completion of this course,
- Students will describe the taxonomy of plants.
- Students will be able to tell the characteristics of different families of plants.

Classification of Plant Kingdom, Life history and phylogeny of Algae, fungi, Bryophyta (*Riccia*), Pteridophyta (*Selaginella*), Gymnosperms (*Pinus*), Angiosperms (*Arabidopsis*).


**Essential Reading**

**Supplementary Reading**

**LS3404  Evolutionary Biology  3 credits (3-0-0)**

**Pre-requisites:**
Biology (LS1001)

**Course Outcomes:**
Early earth and the origin of life; Major events in the history of life; Mechanism of Macroevolution; Phylogeny and the Tree of life, Theories of evolution; Evidence in support of evolution (Morphology to Molecular level); Natural selection, Species concept and Speciation

**Essential Reading**

**Supplementary Reading**
LS3405 GENETICS 3 Credits (3-0-0)

Prerequisites
LS1001 Biology

Course Outcomes
Upon completing this course,

- Students will be able to explain Mendel's principles of inheritance and apply these to problems of inheritance.
- Students will explain how crossing over produces recombination and use of recombination frequencies to construct a genetic map.
- Students will be able to list out the types of mutations and their reasons.


Essential Reading

Supplementary Reading

LS3406 Molecular Biology of Development 3 credits (3-0-0)

Pre-requisites:
Biology (LS1001)

Course outcomes:
At the end of the syllabus,

- Students will be able to explain the development of a cell.
- Students will be able to discuss the expression of genes during the development.
- Students will be able to articulate the process of faulty developments leading to diseases.

Introduction to developmental biology, Overview of the vertebrate development, Developmental Genetics, Techniques used in developmental biology, Molecules regulation of: the early patterning, setting of body axes and germ layers of vertebrates, somites and nervous system, morphogenesis, early embryonic changes, germ cells, fertilization and sex, cell differentiation and stem cells; organogenesis: development of organs; nervous system development.

Essential Reading:

Supplementary Reading:

LS3501 BASIC IMMUNOLOGY 3 Credits (3-0-0)

Prerequisites:
LS1001 Biology

Course Outcomes
By the end of this course,

- Students will understand the concept of host defences against invading pathogens and effective ways of eliminating latter by the former.
- Students will also know the concept of immunotherapy.

Immune system - Lymphoid tissues and organs, Antigens and Immunogens, Innate and adaptive immunity, Immunoglobulins, Antigen-Antibody interactions, B- and T-Lymphocytes, Major histocompatibility complexes, Antigen processing and presentation, Induction, Regulation and effector functions of the immune system, Immunologic memory and tolerance, Complement system, Cell-mediated cytotoxicity, Immunity to infectious and non-infectious agents, Immunoassays - Principles and applications.

Essential Reading

Supplementary Reading
2. Khan Fahim Halim, Elements of Immunology, 2009, Pearson, Delhi, ISBN-9788131711583

LS3102 PHYSIOLOGY 3 Credits (3-0-0)

Prerequisites:
LS1001 Biology

Course Outcomes
At the end of the course,

- Students should acquire knowledge of about different tissues in plants and animals, their coordination and regulation.
- Students should be able to list out various tissues of plants and animals and their functions.
Plant Physiology - Macro and micronutrients and deficiency symptoms, Solute and photoassimilate translocation – Water uptake, Osmosis, Ascent of sap, Phloem translocation Transpiration, Photosynthesis - Pigment system, Cyclic and Noncyclic photophosphorylation, C₃ and C₄ pathways, Photorespiration, Nitrogen metabolism and nitrogen fixation in plants. Secondary Metabolism, Growth and development, Phytochrome, Phytohormones, Photoperiodism, Vernalization, Biological clock, Physiology of flowering.
Animal Physiology – Thermal, Sensory, Digestive, Respiratory, Endocrine, Excretory, Circulation and body fluids, Biological rhythms.

Essential Reading

Supplementary Reading

LS4301 BIOANALYTICAL TECHNIQUES 3 Credits (3-0-0)

Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
Upon completion of this course,
- Students shall understand the principles and applications of advanced techniques in biology.


Essential Reading

Supplementary Reading
LS4103  BIOCHEMISTRY  3 Credits (3-0-0)

Prerequisites
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
Upon completing this course,

- Students will be able to define the molecular logic of life.
- Students will clarify the biological phenomenon regarding chemical concepts.


Essential Reading

Supplementary Reading

LS4407  CELL BIOLOGY  3 Credits (3-0-0)

Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
At the end of the course,

- Students should be able to differentiate various cellular structures.
- Students should be able to discuss functions of cellular organelles.
- Students shall acquire knowledge about cell cycle and cellular trafficking.


Essential Reading

**Supplementary reading**

**LS4602 MICROBIOLOGY 3 Credits (3-0-0)**

**Prerequisites:**
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

**Course Outcomes**
Upon completion of this course,
- Students will understand various concepts in microbiology.
- Students will apply microbiological concepts for basic research.

Ultrastructure of a bacterial cell; Microbial Taxonomy - Nomenclature and Bergey's manual. Classification and characteristics of Fungi, Archaea bacteria and Eubacteria. Microbial nutrition and metabolism - the cultivation of bacteria and central and respiratory metabolism. Control of microorganisms - Antibiotics and antibiotic resistance; Microbial genetics - replication, transcription and translation, mutation, gene transfer, operon; Recombinant DNA technology - vectors, PCR, DNA sequencing, gene editing. Medical microbiology - normal flora, host-pathogen interaction; Environmental Microbiology - biogeochemical cycle, biodegradation, biofilm biology, Microbial degradation of xenobiotics, bioremediation, biofertilizers.

**Essential Reading**

**Supplementary Reading**

**LS4408 Organismal Biology 3 credits (3-0-0)**

**Pre-requisites:**
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

**Course outcomes:**
After the completion of the course,
Students will be able to discuss the general concepts of evolution, natural selection and speciation
Students will be able to explain the plant and animal diversity as well as their phylogeny
Students will be able to articulate the basic information about forms and functions of plants and animals and their environmental adaptations


Essential Reading

Supplementary Reading
1. Biology, by Michael Roberts, Thomas Nelson and Sons Ltd.
2. Discover Biology, Cain, Damman, Lue and Yoon, Sinauer Associate Inc.
3. Biology by Peter H Raven and George & Johnson WCB McGraw Hills

LS4201 BIOINFORMATICS 3 Credits (3-0-0)

Prerequisites
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
Upon completion of this course,

- Students will be able to apply their knowledge to use the biological databases for various applications in biology.
- Students will be able to utilise tools and algorithms in biological applications.
- It will also help students to develop new algorithms in biology.

Computational Biology and Bioinformatics, Biological data and its characteristics, Data formats. Microarray and NGS data. Databases – Primary (NCBI, EMBL, DDBJ) and Secondary (UniGene), Nucleotide sequence databases, Protein sequence databases (SwissProt/TrEMBL, PIR), Sequence motif databases (Pfam, PROSITE), Structure databases (PDB, SCOP, CATH), Gene annotation: Principles and methods. Sequence alignment and database similarity searching, Scoring matrix, BLAST series, FASTA. Pairwise sequence alignments and multiple sequence alignments. Global Alignments – Needleman-Wunsch algorithm, Local Alignments – Smith-Waterman algorithm. Multiple sequence alignments. Phylogenetic markers and molecular phylogeny. Comparative genomics and gene prediction tools. Prediction of the secondary and tertiary structure of proteins, Comparative modelling and docking. Molecular viewers (Cn3D, Rasmol, Swiss-PDB viewer). Overview of programming languages in bioinformatics. Basic commands of UNIX.

Essential Reading

Supplementary Reading

LS4409 DEVELOPMENTAL BIOLOGY 3 Credits (3-0-0)
Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
By the end of this course,

- Students shall understand various concepts of morphogenesis, fertilisation, and gene expression in organ development.


Essential Reading

Supplementary Reading

LS4603 ENZYMEOLOGY AND METABOLISM 3 Credits (3-0-0)
Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
After completing this course,

- Students shall know the principles of catalysis in biological systems.
- Students will understand the reactions of metabolic pathways and their regulatory mechanisms.

Carbohydrate Metabolism, Amino acid metabolism, Lipid metabolism, Nucleic acid metabolism, Mechanism of selective reactions, Regulation of metabolic pathways, Metabolic disorders.

**Essential Reading**

**Supplementary Reading**

**LS4104 MOLECULAR BIOLOGY**

**3 Credits (3-0-0)**

**Prerequisites:**
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

**Course outcomes**
At the end of the course,
- Students will be able to decode the necessary signals programmed and stored in the chromosome.
- Students will be confident to explore and solve the disorders of life processes.


**Essential Reading**

**Supplementary Reading**
LS4410  MOLECULAR GENETICS  3 Credits (3-0-0)
Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
Upon completing this course,

- Students will be able to explain the main principles of Mendelian Genetics.
- Students will be able to discuss the main methods to study gene mapping.
- Students will be able to describe mutations and evolutionary genetics.


Essential Reading

Supplementary Reading
1. Puehler A, Timmis, KN: Advanced Molecular Genetics, Springer Berlin Heidelberg publication (2011)

LS5604  ECOLOGY AND ENVIRONMENTAL SCIENCES  3 Credits (3-0-0)

Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
After completing this course,

- Students will be able to explain the origin of life.
- Students will be able to describe various geographical zones and biomes.
- Students will be able to discuss ecological aspects of population, community and species.


Essential Reading
1. Environmental Science by S. C. Santra, New Central Book Agency, India

Supplementary Reading

LS5502 IMMUNOTECHNIQUES 3 Credits (3-0-0)

Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
Upon completing this course,
- Students will be able to explain the principles involved in various immunological techniques.
- Students will be able to discuss the basics and applications of various diagnostic tests currently in use for various diseases.


Essential Reading

Supplementary Reading

LS5202 APPLIED BIOLOGY 3 Credits (3-0-0)

Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
By the end of this course,
- Students will get an idea on how biological processes have been hamessed for the welfare of humankind.
Students will get to know success stories of biological applications in agriculture, industry and healthcare which may inspire them to explore more in this field in future by utilising their knowledge and expertise.

Definition and scope of applied biology, Branches of biology, Bioprocess technology for the production of cell biomass and primary/secondary metabolites, Regeneration of plants and Totipotency, Hairy root cultures and their cultivation, Transgenic plants in crop protection and their application in agriculture – Herbicide tolerant plants, Disease resistant plants, Insect tolerant plants; Plant products of industrial importance, Cloning in animals, Genetic engineering, transgenic animals, gene therapy, Genetically manipulated organisms and products, GM Foods and current global situation, Pharmaceuticals, Drug Delivery.

Essential Reading

Supplementary Reading

LS5605 AQUATIC BIOLOGY AND MARINE BIOTECHNOLOGY 3 Credits (3-0-0)

Prerequisites:
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

Course Outcomes
By the end of this course,
- Students will be able to describe aquatic biomes.
- Students will be able to list out names of marine bioresources.
- Students will be able to explain about the aquaculture technology and marine biotechnology.


Essential Reading
Supplementary Reading

LS3302 BIOINSTRUMENTATION 3 Credits (3-0-0)

Prerequisites
LS1001 Biology

Course Outcomes
Upon completion of this course,

➢ Students shall be able to apply different instrumentation for their biological research, and shall be able to modify the technique for project’s suitability.

Principles, types and applications of pH meter, Spectrophotometers, Centrifuges, Microscopes, Sonicator, Autoclave, Biosafety cabinets, Electrophoretic techniques, Precipitation, Dialysis, Ultrafiltration, Lyophilization, Chromatography.

Essential Reading

Supplementary Reading
1. Cantor, Schimmel. Biophysical Chemistry (Techniques for the study of biological structure and function), (part II) (1980).

LS3303 BIOPHYSICS 3 Credits (3-0-0)

Prerequisites:
LS1001 Biology

Course Outcomes
By the end of this course,

➢ Students shall be able to understand the rules of physics involved in the biological system.


Essential Reading

Supplementary Reading

LS5411 CANCER BIOLOGY 3 Credits (3-0-0)
Prerequisites: LS4407 Cell Biology

Course Outcomes
After completing this course,
➢ Students shall be able to discuss the basic concepts of cancer, its causative agents, molecular mechanism and immunoediting.


Essential Reading

Supplementary Reading

LS5105 Chromatin Dynamics and Gene Regulation 3 Credits (3-0-0)
Prerequisites: LS4104 Molecular Biology

Course outcomes:
Upon completion of the course,
➢ Students will be able to explain about chromatin structure and gene regulation in detail
➢ Students will be able to describe the concept of epigenetics and its effect

Genome architecture, gene function, Chromatin organisation and gene expression, Stem cells, Reprogramming and Regeneration, Epigenetics, Regulation of genes in eukaryotes, Structural genomics, alteration in gene regulation and diseases, Modulation of chromatin dynamics

Essential Reading
LS3606  FOOD SCIENCE  3 Credits (3-0-0)

Prerequisites
LS1001 Biology

Course Outcomes
After completing this course,

- Students shall be able to explain the basics of food chemistry, nutrition and food microbiology.
- Students shall be able to discuss the processing technologies followed in industries.
- Students shall be able to relate the subject to the possible arena of entrepreneurial activity related to food products.

Specific components of foods – Carbohydrates, proteins, lipids, dietary fibres, pigments, flavours. Enzymatic and Nonenzymatic browning, Basic concepts of nutrition - Nutritional and Calorific values of foods, Protein Efficiency Ratio, Role of vitamins and minerals in nutrition, Antinutrients, Nutrition deficiency diseases, Microbial growth in food, Growth and Death kinetics, Food spoilage – Chemical, Thermal and Microbial causes, Foodborne diseases, Fermented Foods, Food processing principles, Hurdle Technology, Preservatives, Food additives.

Essential Reading

Supplementary Reading

LS5304  GENOMICS AND PROTEOMICS  3 Credits (3-0-0)

Prerequisites:
LS4104 Molecular Biology

Course Outcomes
Upon completing this course,

- Students shall be able to discuss the concept about genomics and proteomics.
- Students shall be able to explain about Transcriptomes.

Definition, classification, and scopes. The emergence of proteome concept - Structural and functional proteomes, Protein structure related to functional kinetics. Prions, Bridging genomics to proteomics. Transcriptomes - Measurement of gene expression, Microarray,
RNA-seq, Proteome analysis - 2-D PAGE including protein detection on electro-blot membrane, Mass spectrometry and Phosphorylation site analysis. Proteomics about animal and plant health and welfare.

**Essential Reading:**

**Supplementary Reading:**

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**LS5412 Molecular Evolution**

**Pre-requisites:**
Biology (LS1001)

**Course outcomes:**
After the completion of the course,
- Students will be able to discuss the theories of evolution
- Students will be able to explain the molecular evolution

History of evolutionary ideas, Evolution of Biodiversity, Genetic variation natural selection, units of selection, adaptation, speciation, population genetics, drift and the neutral theory, sexual selection and the evolution of sex, molecular phylogenetics, molecular evolution, estimating nucleotide substitutions, homologous sequences, gene trees vs. species trees, Darwinian selection at the molecular level, gene families. Evolution of genes and genomics, Co-evolution- interactions amongst species

**Essential reading:**
2. Rajeev Tyagi, Understanding Evolutionary Biology, Discovery Publishing House Pvt Ltd (2011),

**Supplementary reading:**

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**LS5503 Nanobiology**

**Pre-requisites:**
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

**Course outcomes:**
After completion of the syllabus,
- Students will be able to discuss the concepts in nanobiology
- Students will be able to explain the applications of nanotechnology in different fields of biology

Nanoparticles and their types, Biopolymeric formulations, Different methods of synthesis of nanomaterials, Characterization techniques of nanomaterials, Nanomaterials as drug
delivery systems, Multifunctional nanoparticle platforms, Nanoparticle interface at the molecular level, Nanotoxicity.

**Essential Reading:**

**Supplementary Reading:**

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**LS5413 Neuroscience**

**Pre-requisites:**
Biology (LS1001)

**Course outcomes:**
After the completion of the syllabus,
- Students will be able to explain about the neuronal wiring in various parts of our body.
- Students will be able to discuss how our sensory organs work and maintain coordination with the surrounding.
- Students will be able to articulate the deformities caused in the body by the failure of organs.

Gross anatomy of the central, peripheral and autonomous nervous system; basic circuit, synaptic action, dendritic properties and functional operation of: Peripheral nervous system; Functional aspects of cranial and spinal nerve components; functional anatomy of Cerebellum; cerebellar cortex, central nuclei, cerebellar peduncles; Descending motor pathways; Neuronal structural and functional operation of: Auditory system; Visual system; Olfactory and Limbic system; Autonomic system.

**Essential Reading:**

**Supplementary Reading:**

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**LS5607 Parasitology**

**Prerequisites:**
Microbiology (LS4602)

**Course Outcomes:**
Upon completing the course,
- Students will be able to discuss the concept of parasitism and animal associations.
Students will be able to tell the major types of protozoan parasites and their life cycles.
Students will be able to articulate helminthic parasites.
Students will be able to explain methods to identify parasites and to treat parasitic infections.


**Essential Reading:**

**Supplementary Reading:**

**LS5203   Recombinant DNA Science   3 Credits (3-0-0)**

**Pre-requisites:**
Biochemistry (LS4103), Cell biology(LS4407), Microbiology(LS4602), Molecular Biology (LS4104)

**Course outcomes:**

By the end of the course, the students will be able to:
- The benefit with detailed concept/knowledge on current molecular biology and application.
- Apply the recombinant DNA science in routine laboratory application and practices. Provide examples on the use of rDNA science to engineering bacteria, plant or animal cell to produce a protein of interest.
- Can design step-by-step research problems on bioengineering any organism.

Tools of recombinant DNA, c-DNA and genomic library, oligonucleotide synthesis, Molecular markers, DNA sequencing, Functional Genomics, Gene isolation, cloning, expression and identification of recombinant clone and expression of the protein in bacteria and eukaryotic cells. Regulating Use of Biotechnology, Patenting Biotechnology Inventions.

**Essential reading:**

**Supplementary reading:**
2. Recombinant Enzymes - From Basic Science to Commercialization Amid, Azura. Cham: Springer. 2015. eBook., Database: eBook Index
LS5204 RNAi and Oncogenomics 3 Credits (3-0-0)

Prerequisites:
LS4407 Cell Biology, LS4104 Molecular Biology

Course Outcomes
- After completion of the syllabus, students will be equipped to use the concept of RNAi and gene silencing as a useful tool for studying various biological problems, especially cancer and stem cells.

The concept of RNAi (RNA interference) and discovery, Gene silencing, Gene activation, other methods of gene silencing. Types, Biogenesis and Regulatory roles of non-coding RNAs - miRNA, siRNA, piRNA, IncRNA, RNAi-mediated gene silencing - Components and Mechanism, RISC and Proteins. The role of RNAi in development and differentiation. Oncogenesis, Tumour suppressor genes and Oncogenes. Cross-talk among ncRNAs and cancer, RNAi in oncogenesis and stem cells, Regulatory RNAs in cancer and cancer stem cells (CSCs), Types of stem cells, RNAi in induced pluripotency and cancer, Current research progress in RNAi therapeutics - case studies, significance and challenges.

Essential Reading

Supplementary Reading:

LS5106 STRUCTURAL BIOLOGY 3 Credits (3-0-0)

Prerequisites
LS4103 Biochemistry

Course Outcomes
- After completing this course,
  - Students should be familiar with the NMR, X-ray and computational techniques used to study macromolecular structure.
  - Students will understand the basics of various types of macromolecular interactions.

The concept of Structural Biology, Evolutionary relationships of structural features of proteins. Determinants of protein structure and current views of protein folding. Motions in macromolecules and the functional importance of dynamics, the basis for various types of macromolecular interactions including protein- protein and protein-nucleic acid interactions, the chemical basis for interactions with enzyme inhibitors and other ligands. X-ray crystallographic and NMR-structure of proteins and nucleic acids. The proposition of DNA double helical structure in understanding the blueprint of life, Watson and Crick model. Fine structure of fibrous, globular and membrane proteins, Nucleosome and Chromatin structure. Cytoskeleton structure and protein-protein network.

Essential Reading

**Suggested Reading**


**LS5414 SYSTEM PHYSIOLOGY 3 Credits (3-0-0)**

**Prerequisites:**
B.Sc. level biology related subjects / Integrated M.Sc. 3 years study

**Course outcomes**

Upon completion of this course,

- Students will understand the structure of various systems in human body.
- Students will be able to explain about the functions of different systems of human body.
- Students will understand the malfunctioning of systems in the human body and its remedial measures.


Water and Solute transport, Photoassimilate translocation, Photorespiration, Plant hormones and phytochromes-physiological effects and mechanisms of action, Secondary metabolites, Stress physiology

**Essential Reading**


**Supplementary Reading**

1. Watson Cheryl, Human Physiology, 2015, Jones and Bartlett Learning titles in biological science, Joes and Bartlett, Burlington, ISBN-9781284035179

**LS2107 BIOMOLECULES 3 credits (3-0-0)**

**Pre-requisites**
LS1001 Biology
Course Outcomes:

On successful completion of this course, students should be able to:

- Explain properties of water and how they influence biomolecular and cellular function.
- Develop the knowledge of the structural organisation and functional molecules of the cells namely carbohydrates, lipids, proteins and nucleic acids.
- Describe the structure, chemistry and functional roles of biomolecules, including nucleic acids, lipids, carbohydrates and proteins.
- Understand the different classes of enzymes and vitamins present in the living system and how they participate, perform and regulate different chemical reactions.

Water - chemical properties, function as medium of cellular reactions and activities; Carbohydrates- structure, functions and biologically important carbohydrates Amino acid, peptide and proteins - classification, structure and properties of amino acids, Protein-structures and function; Lipids- structure and biological functions; Nucleic acids- DNA-double helix structure and function, RNA- structure and functions Enzymes- classification of enzymes and mechanism of enzyme action; Vitamins-Structure and functions.

Essential Reading


Supplementary Reading


LS2415 Cellular Architecture and Mechanics 3 Credits (3-0-0)

Prerequisite:
LS1001 Biology

Course Outcomes

After completion of the course,

- Students will be able to list out the cellular organelles and explain their functions
- Students will be able to discuss the differences between prokaryotic and eukaryotic cells in detail
- Students will be able to explain the central dogma of cell and cellular communication processes


Essential Reading


Supplementary reading

LS3608 Microbes and Environment 3 Credits (3-0-0)

Pre-requisites:
Biology (LS1001)

Course Outcomes:
Upon completing this course,
- Students will have the know-how on the various uses of microorganisms.
- Students will have an overview of the effect of microbes on the environment.

Microbial cell structure and function, Aerobic and Anaerobic Respiration, Microbial Ecology, Environmental Microbiology, Role of microbes in different biogeochemical cycles, Microbial Fertilizers and Microbial Pesticides, Waste water treatment, Biodegradation and Bioremediation; Aquatic microbiology and water-borne diseases. Microbial interactions and interrelations with other organisms.

Essential Reading:

Supplementary Reading:

LS3504 Infection and Immunity 3 Credits (3-0-0)

Pre-requisites:
LS1001 Biology

Course Outcomes
Upon completing the course,
- Students will be able to discuss the concept of microbial infection and immune response against them.
- Students will understand about major human pathogens and associated disease outcome
- Students will be able to explain how our immune (defence) system function

Basic immunology, Innate and adaptive immunity, immune cells. Infection biology, type of infection, Bacterial, viral, fungal, parasitic, protozoan infections. Immune response to bacterial (Salmonella and Mycobacterium) and viral (HIV, Influenza) infection. Pathogenicity and virulence factors. Vaccine development and its importance

Essential Reading

**Supplementary Reading**

**LS4205 Bioinformatics and Genome Biology 3 Credits (3-0-0)**

**Pre-requisites:**
LS1001 Biology

**Course outcomes:**
On completion of the syllabus,
- The student will be having an in-depth understanding of the organisation and content of the genomes
- The student will be able to explain how the genomes can be harnessed by different approaches of bioinformatics to draw conclusions about function, evolution and hidden treasures of the organisms.

Genome structure and composition, Factors that influence the size, content and function of the genome, human genome and genome projects, overview of genomics and bioinformatics, Genome sequencing, Genome annotation and gene prediction, sequence analysis of genes, genomes and biological data sources, Comparative Genomics, Phylogenetics and phylogenomics, Functional genomics, 3D structure and structural genomics, metagenomics, genome-wide profiling methods, Next-generation sequencing technologies and analysis, Epigenomics, systems biology and gene regulatory networks.

**Essential reading:**

**Supplementary reading:**

**LS4416 Molecular Biology of Development 3 credits (3-0-0)**

**Pre-requisites:**
Biology (LS1001)

**Course outcomes:**
At the end of the syllabus,
Students will be able to explain the development of a cell.
Students will be able to discuss the expression of genes during the development.
Students will be able to articulate the process of faulty developments leading to diseases.

Introduction to developmental biology, Overview of the vertebrate development, Developmental Genetics, Techniques used in developmental biology, Molecules regulation of : the early patterning, setting of body axes and germ layers of vertebrates, somites and nervous system, morphogenesis, early embryonic changes, germ cells, fertilization and sex, cell differentiation and stem cells; organogenesis: development of organs; nervous system development.

**Essential Reading:**

**Supplementary Reading:**

**LS2091 Life Science Laboratory I**
2 credits (0-0-3)

**Prerequisites:**
Enrolling into LS2101 Basic Biochemistry, LS2601 Basic Microbiology, LS2401 Cell and Molecular Biology

1. Detection of carbohydrate, proteins, lipids, and nucleic acid.
2. Estimation of blood glucose.
3. Estimation of blood urea.
4. Observation of a plant cell.
5. Observation of an animal cell.
6. Observation of different phases of mitosis.
7. Observation of different phases of meiosis.
8. Preparation of nutrient broth and nutrient agar slants/plates and observation of microbial growth.
9. Isolation and enumeration of total heterotrophic bacteria by spread plate technique.
10. Isolation and enumeration of total heterotrophic bacteria by pour plate technique.

**LS2092 Life Science Laboratory II**
2 credits (0-0-3)

**Prerequisites:**
Enrolling into LS2402 Animal Science, LS2403 Plant Science

1. Demonstration of three most distinctive features of plant cells – plastids, the large central vacuole and cell walls by compound microscope.
2. Observation of photosynthetic plant cell from the water plant *Elodea*.
3. Observation of amyloplasts in yam sections and tomato fruit.
4. Observation of cell walls in cork, stone cells in pear fruits, parenchyma and sclerenchyma cells in a grass leaf.
5. Observation of plant structures – stems and leaves.
6. Observation of animal cells.
7. Observation of different internal parts of animals.
8. Observation of different parts of digestive tract of cockroach.

**LS3093  Life Science Laboratory III**  
**Prerequisites:** Enrolling into LS3405 Genetics, LS3406 Molecular Basis of Development

1. Observation of different stages of chick embryo.
2. Observation of different stages of frog.
3. Observation of different stages of fish embryo.
4. Structure of sperm and egg.
5. Observation of different stages of pollen development in Arabidopsis.
7. Experiment on Polygenic inheritance.
8. Experiment on Simple Cross in *Arabidopsis* (mutant vs wild type).

**LS3094  Life Science Laboratory IV**  
**Prerequisites:** Enrolling into LS3501 Basic Immunology, LS3102 Physiology

1. Study of Blood Groups.
3. Detection of specific antigen using Double Immuno-diffusion technique.
4. Latex Agglutination test for Rheumatoid arthritis.
5. Widal test for Typhoid.
6. Determination of water potential by tissue weight change method.
7. Study of the stomatal index.
8. Relation between water absorption and transpiration.

**LS4391  Bioanalytical Techniques Lab**  
**Prerequisites:** Enrolling into LS4301 Bioanalytical Techniques

1. Preparation of different solution (protein, lipid, nucleic acid) for FTIR, UV-Visible, Fluorescence spectroscopic measurements.
2. DNA melting and reannealing study using UV-Visible spectroscope.
4. Effect of different solvent on fluorescence property of intrinsic/extrinsic fluorophore using fluorescence spectroscope.
5. Preparation of different acid/base dilution to differentiate between activity and concentration.
7. Purification of protein using size exclusion chromatography.
8. Determination of concentration of sugars using HPLC.

**LS4491  Cell Biology Lab**  
**Prerequisites:** Enrolling into LS4407 Cell Biology

1. Measurement of the size of cells and subcellular components in light microscope.
2. Staining of nucleus, mitochondria in human cheek epithelial cells.
4. Study of apoptosis, autophagy and senescence in Mammalian cells.
5. Study of different stages of mitosis in onion root tip cells.
6. Study of different stages of meiosis in grasshopper testis cells.
7. Analysis of expression of fluorescent-tagged proteins by transfection in eukaryotic cell.
8. Analysis of expression of protein by Western blot.

LS4691   Microbiology Laboratory   2 Credits (0-0-3)

Prerequisites:
Enrolling into LS4602

1. To study the guidelines for working in the microbiology laboratory.
2. To study various aseptic techniques used in the microbial experiment.
3. Isolation of total heterotrophic bacteria from soil and water.
4. Enumeration of air-borne microorganisms.
5. Isolation of pure culture.
6. To perform Gram’s staining to distinguish Gram-positive and Gram-negative bacteria.
7. Simple staining of bacteria and fungi.
10. Determination of Minimum Inhibitory Concentration (MIC) of antibiotics.
11. To test starch hydrolysis by amylase activity.
12. To study bacterial motility.
13. To study bacteriology of water by Most Probable Number (MPN) method.
14. To study principle and procedure of IMViC test.
15. To study microbial catabolic gene expression.
16. Bio-reporter assay for screening biofilm forming bacteria
17. Qualitative and quantitative assessment of bacterial biofilm

LS4191  Biochemistry and Molecular Biology Lab  2 Credits (0-0-3)

Prerequisites:
LS4103 Biochemistry and enrolling into LS4104 Molecular Biology

1. Estimation of blood glucose and detection of (i) urea, (ii) uric acid, (iii) creatine, (iv) creatinine, and (v) bile pigment in serum.
2. Determination of (i) sugar, (ii) ketone bodies, and (iii) protein in urine sample.
4. Determination of lipid, total cholesterol, LDL, HDL and triglycerides.
5. Purification of serum albumin.
7. Protein fractionation – (i) Salting in and out, (ii) Gel filtration and affinity based techniques, (iii) SDS-PAGE, and (iv) Electrophoretic separation of LDH isoenzymes.
8. Absorption and fluorescence spectroscopy related experiments.
10. Isolation of DNA from prokaryotic and eukaryotic cells.
11. Isolation of RNA from prokaryotic and eukaryotic cells.
12. Isolation of plasmid DNA from microorganisms.
13. Preparation of cDNA.
15. Preparation of competent cells.
16. Cloning of external DNA into a plasmid vector.
17. Expression of foreign genes in Escherichia coli.

LS4291  Bioinformatics Lab  2 Credits (0-0-3)

Prerequisites:
Enrolling into LS4201 Bioinformatics
1. Visualising and understanding biological data formats, such as GenBank flat file, genpet, FASTA, nexus, pdb etc.
3. Protein Databank (PDB).
4. Interpretation of different biological data and use of tools of NCBI.
5. Visualising and understanding the 3D structure of macromolecules by molecular viewers: RasMol, Cn3D, Swiss-PDB Viewer.
7. Protein secondary structure and prediction using available freeware.
8. Comparative genomics and gene prediction.

**LS5591 Immunology Lab**
2 Credits (0-0-3)

**Prerequisites:**
Enrolling into LS5502 Immunotechniques

1. Isolation of Peripheral Blood Mononuclear Cells.
2. Detection of antigen/antibody using Enzyme Linked Immunosorbent Assay technique.
4. Detection of specific antigen/antibody using the Immunoblotting method.
5. Fluorescent labelled antibody technique.
6. Purification of Immunoglobulins.
7. Purification of antisera.
8. Agglutination reactions.
10. Separation of cells using Magnetic Activated Cell Sorting technique.

**LS3095 Life Science Minor Laboratory – I**
1 credit (0-0-2)

**Prerequisites:**
LS2107 Biomolecules, LS2415 Cellular Architecture and Mechanics, and enrolling into LS3608 Microbes and Environment

1. Detection and estimation of protein
2. Detection and estimation of carbohydrate
3. Enzyme assay
4. Microscopic examination of pure and mixed microbial cultures and serial dilution and spread plating of mixed microbial cultures
5. Streak plating, microscopy and gram staining techniques
6. Handling of liquid cultures and monitoring microbial growth phases via spectrophotometry
7. Observation of a plant cell.
8. Observation of an animal cell.
9. Observation of different phases of mitosis.
10. Observation of different phases of meiosis.

**LS4096 Life Science Minor Laboratory – II**
1 credit (0-0-2)

**Prerequisites:**
LS3504 Infection and Immunity, LS4205 Bioinformatics and Genome Biology, and enrolling into LS4416 Molecular Biology of Development

1. Study of blood groups
2. Determination of HCG hormone
3. Protein structure and function
4. Homology modelling
5. Comparative genomics
6. Pattern matching
7. Phylogenetics
8. Drosophila life cycle
9. Experiment on eye development
10. Mechanosensory organ development

DEPARTMENT OF MATHEMATICS

MA 1001 DIFFERENTIAL, INTEGRAL AND VECTOR CALCULUS (Math I)
4 credits [3-1-0]

Differential Calculus: Real number system, Completeness axiom, Sequence (monotone, bounded and Cauchy sequences), Limits, Continuity and Differentiability of functions, Rolle’s Theorem, Mean value theorems, Series of real numbers, Tests for convergence of Series, Taylor’s and Maclaurin’s theorems with remainders, Indeterminate forms. Functions of several variables—Partial Differentiation, Total Differentiation, and Change of variables—Jacobians, Maxima and minima of functions of two and three variables—Lagrange’s method of Multipliers.

Integral Calculus: Riemann integration, Introduction to improper integrals, Beta and Gamma integrals, Differentiation under integral sign; Double and triple integrals.


Essential Readings:

MA 1002 ORDINARY DIFFERENTIAL EQUATIONS AND MATRIX THEORY (Math II)
4 credits [3-1-0]

Matrix Theory: Gauss elimination method, Gauss-Jordon method for finding inverse of a matrix, Vector space, subspace, linear span, linear dependence and independence, Basis and dimension of vector space, Row and column spaces, Rank and nullity of a matrix, Rank and Nullity Theorem, Inner product spaces, Gram-Schmidt Orthogonalization, Matrix representation of Linear Transformations, Solvability of systems of linear equations, Eigen values, Eigen vectors, Diagonalization of matrices, Reduction of a quadratic form to canonical form.

Ordinary differential equations of first order: Geometrical interpretations, Separable equations, Reduction to separable form, Exact equations, Integrating factors, Linear equations, Bernoulli equations, orthogonal trajectories, Existence and uniqueness of IVP (Picard’s Theorem), Applications to physical problems.

Ordinary linear differential equations of higher order: Fundamental system and general solutions of homogeneous equations of order two, Wronskian, reduction of order, Solution of non-homogeneous equations by method of undetermined coefficients and variation of parameters. Extension to higher order differential equations, Euler-Cauchy equation, Power series method, Applications to physical problems.

Laplace Transform: Laplace and inverse Laplace transforms, existence of Laplace transform, first shifting theorem, transforms of derivative and integral, second shifting
theorem, differentiation and integration of transforms, Convolution theorem, Solution of ordinary differential equations with constant coefficients.

Essential Reading:

Suggested Readings:
4. Kawk And Hong, Linear Algebra
5. N. Piskunuv, Differential and Integral Calculus

MA 2103        INTRODUCTION TO REAL ANALYSIS                                3 Credits [2-1-0]

Basic concepts: Real number system and set theory, Completeness property, Archimedean Property, Denseness of rational and irrational numbers, Countable and uncountable sets, Cardinality, Review of limit, continuity and differentiability of functions, Uniform continuity of a function.


Metric spaces: Open and closed sets, interior and closure of a set, Limit points, Continuous functions, Sequences in a Metric Space, Cauchy Sequences and Completeness, Compactness, Finite intersection property, Total boundedness, Baire category theorem, Cantor's intersection theorem, Completion of a metric space.

Essential Readings:

Suggested Readings:

MA 2104        INTRODUCTION TO COMPLEX ANALYSIS                                4 Credits [3-1-0]

Limit, Continuity and Differentiability, Analytic function, Cauchy Riemann equations, Laplace’s equation, Conformal mapping, branch and branch point, Linear fractional transformations, Complex integration, Line integral in the complex plane, Cauchy’s Integral Theorem, Cauchy’s Integral Formula, Liouville’s theorem, Morera’s Theorem Sequences, Series, Convergence tests, Power series, Functions given by power series, Taylor’s,
Maclaurin’s and Laurent’s series, Uniform convergence, Zeros, Limit point of Zeros, Singularities, Poles, Residue theorem, Evaluation of real integrals.

**Essential Reading:**

**Suggested Reading:**

**MA 2305 INTRODUCTION TO NUMERICAL ANALYSIS 4 Credits [3-1-0]**

**Essential Reading:**

**Suggested Reading:**

**MA 2106 NUMBER THEORY 3 Credits [2-1-0]**
Division Algorithm, Prime and composite numbers, Fibonacci and Lucas Numbers, Fermat numbers, Greatest common divisors, Euclidean algorithm, Fundamental theorem of arithmetic, Linear Diophantine equations, Congruences, Complete residue systems, Linear Congruences, System of linear congruences, Chinese remainder theorem, Pollard rho factoring methods, Wilson’s theorem, Fermat’s little theorem, Euler’s theorem, Pollard \( p – 1 \) factoring method, Multiplicative functions, Euler’s phi function, Tau and sigma functions, Perfect numbers, Mersenne primes, Primitive roots and indices, Order of a positive integer, Primality test, Primitive roots of primes, Algebra of indices, Cryptology, Affine ciphers, Hill ciphers, Exponentiation ciphers, The RSA cryptosystem, The Knapsack ciphers.

**Essential Reading:**

**Suggested Reading:**

**MA 3101 INTRODUCTION TO ALGEBRA 3 Credits [2-1-0]**
Groups, Subgroups, Cyclic groups, Normal Subgroups and Quotient groups, Lagrange’s theorem, Centralizers, Normalizers, Homomorphisms, Isomorphism theorems, Symmetric groups, Simplicity of the Alternating group, Matrix groups, Direct products of groups, Fundamental theorem of finitely generated abelian groups, Sylow Groups, Rings, Integral Domains, Ideals, Ring of fractions, Ring homomorphisms, Polynomial rings, Fields.

**Essential Reading:**
Suggested Readings:

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**MA3202  LINEAR PROGRAMMING  3 credits [3-0-0]**

Basic linear algebra, Lines and hyperplanes, convex sets, convex hull and their properties, Formulation of a Linear Programming Problem, Theorems dealing with vertices of feasible regions and optimality, Graphical solution, Simplex method (including Big M method and two phase method), infeasible and unbounded LPP’s, alternate optima, Dual problem and duality theorem. Transportation problems, existence of solution, degeneracy, MODI method, Assignment problem, Travelling salesman problem. Introduction to theory of games, Minimax (max-min) criterion and optimal strategy, Solution of games with saddle points.

Essential Reading:

Suggested Readings:

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**MA 3304  MATHEMATICAL METHODS  4 Credits [3-1-0]**

*Fourier Series and Transform:* Expansion of a function in Fourier series for a given range and its convergence, Even and odd functions, Half range sine and cosine expansions, Fourier integrals, Complex Fourier series, Fourier transform, Inverse Fourier transform, Properties of Fourier transform, Convolution theorem, Discrete Fourier transform. Second order partial differential equations, Normal Form, Solutions of wave equation, Heat equation and Laplace’s equation and their use in problems of vibrating string, one dimensional unsteady heat flow and two dimensional steady state heat flow

*Integral Equations:* Classification of Integral equations, Neumann’s iterative method for Fredholm’s equation of second kind, Volterra type integral equation, Integral equations of first kind, Convolution type Integral Equations.

*Calculus of Variations:* Functionals, Variation of functionals, Example of variation problems, Euler’s equation, sufficient conditions for the extremum of a functional, conditional extremum, Rayleigh-Ritz method.

Essential Readings:

Suggested Reading:

**MA 3203  Introduction to PROBABILITY and Statistics  4 credits [3-1-0]**


**Essential Reading:**

**Suggested Readings:**

**MA 3206  DISCRETE MATHEMATICS  3 credits [3-0-0]**


**Essential Reading**:

**Suggested Readings**:

**MA 3370  Computing Laboratory  2 credits [1-0-2]**
Experiments on numerical methods for root finding, solving linear system of equations, interpolation, Eigen value problems, numerical differentiation, integration and solution of ordinary differential equations.

**MA 4101 REAL ANALYSIS 3-Credits [3-0-0]**


**Essential Reading:**

**Suggested Readings:**

**MA 4102 MEASURE THEORY 3 credits [3-0-0]**


**Essential Readings:**

**Suggested Readings:**

**MA 4103 COMPLEX ANALYSIS 3 credits [3-0-0]**

Spherical representation of extended complex plane, Analytic functions, Branches of multiple-valued functions, Cauchy’s theorem, Singularities, Argument principle, Calculus of residues, Harmonic functions, Poisson’s formula, reflection principle, Conformal mappings,
Geometry of Mobius transformations, Open mapping theorem, Maximum modulus theorem, Schwarz's lemma, Partial fractions and factorization, Stirling's formula, Jensen's formula, Hadamard's theorem, Little and Great Picard Theorem.

**Essential Readings:**

**Suggested Reading:**

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**MA 4104 ALGEBRA 3 credits [3-0-0]**


**Essential Readings:**

**Suggested Readings:**

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**MA 4305 NUMERICAL ANALYSIS 3 credits [3-0-0]**


**Essential Readings:**

**Suggested Reading:**
MA 4106  TOPOLOGY  3 credits [3-0-0]

*Topological spaces and continuous functions:* Topological spaces, Basis for a topology, Order topology, Product topology, Subspace topology, Closed sets and limit points, Continuous functions, Homeomorphism, Metric topology, Quotient topology.

*Connectedness and compactness:* Hausdorff spaces, Connected spaces, Connected subspaces of the real line, Compactness and local connectedness, Compact spaces, Compact subspaces of the real line, Tychonoff Theorem, Limit point compactness, Local compactness, Compactification, One-point compactification, Stone-Cech compactification.

*Countability and separation axioms:* Countability axioms, Separation axioms, Normal spaces, Regular spaces, Completely regular spaces, Urysohn lemma, Urysohn metrization theorem, Tietze extension lemma.

**Essential Reading:**

**Suggested Readings:**

MA 4107  LINEAR ALGEBRA  3 credits [3-0-0]


**Essential Readings:**

**Suggested Readings:**

MA 4208  STOCHASTIC PROCESS  3 credits [3-0-0]

Stochastic Processes: Definition and examples of stochastic processes, Classifications of stochastic processes, Markov chains: Definition and examples, Transition Probability matrices, Chapman-Kolmogorov equations, Random walk, Classification of states of a Markov chain, Determination of higher order transition probabilities, Graph theoretic approach, Markov chains with denumerable number of states, Reducible Markov chains,

**Essential Reading:**

**Suggested Reading:**

**MA 4371 PROGRAMMING PRACTICE LABORATORY** 2 Credits [1-0-2]

**Prerequisites:** MA 401, MA 403 and vector analysis

Basic Matrix constructions, basic MATLAB operations, conditional statements–for, while, if, subprogram, basic Mathematical operations like +,−,*,/,. etc. Based on the above knowledge some problems on Real Analysis, vector analysis, linear algebra.

**MA 4272 STATISTICS LABORATORY** 2 Credits [1-0-2]

**Prerequisites:** MA 408

Experiments for calculation of A.M., G.M., H.M., median, mode, quartiles, deciles, percentiles, deviation, moments etc.

**MA 4373 Numerical Methods Laboratory** 2 credits [1-0-2]

Experiments on numerical methods for root finding, solving linear system of equations, interpolation, Eigen value problems, numerical differentiation, integration and solution of ordinary differential equations.

**MA 5101 FUNCTIONAL ANALYSIS** 3 credits [3-0-0]


**Essential Reading:**

**Suggested Readings:**
MA 5303 PARTIAL DIFFERENTIAL EQUATIONS 3 credits [3-0-0]

Origin of first order partial differential equations, Cauchy’s problem, Linear equations, Integral surfaces passing through a given curve, Surfaces orthogonal to a given system of surfaces, Nonlinear partial differential equations of the first-order, Cauchy’s method of characteristics, Compatible systems of first-order equations, Charpit’s method, Jacobi’s method, Second and higher order equations in physics, Linear partial differential equations, Characteristic curves, Separations of variables, Integral transform method for parabolic, hyperbolic and Elliptic equations.

**Essential Readings:**

**Suggested Readings:**

MA 5110 FOURIER ANALYSIS 3 credits [3-0-0]

*Fourier Series*: Definition, Examples, Uniqueness of Fourier Series, Convolution, Cesaro and Abel summability of Fourier Series, Fejer’s theorem, Poisson kernel and Dirichlet problem in the unit disc, Mean square convergence of Fourier series.

*Fourier Transform*: The Schwartz space, Fourier transform on the real line and basic properties, Fourier inversion formula, L¹(2) theory, The class of test functions, Distributions, differentiation and convolution of distributions, Tempered distributions, Fourier transform of a tempered distribution.


**Essential Readings:**

**Suggested Readings:**

MA 5111 DIFFERENTIAL GEOMETRY 3 Credits [3-0-0]
Definition of Space Curve, Arc length, Tangent, Normal, Binormal, Tangent and Osculating Plane, Principal Normal and Binormal, Curvature and Torsion, Serret-Frenet formulae, Curves on a surface, Contact between curves and Surfaces, Osculating Circle and Osculating Sphere, Tangent Surfaces, Involutes and Evolutes, Intrinsic equation of space curves, Fundamental existence theorems for space curves, Surface representation, Regular and Singular points, Change, Tangent plane and normal, Surfaces of Revolution, Metric on a Surface- The first fundamental form, Invariance of the metric, Direction coefficients on a Surface, Double family of curves, Isometric correspondence, Intrinsic properties, Geodesics and their Differential Equations, Canonical Geodesic equations, Geodesics on a surface of revolution, Gauss-Bonnet theorem, Second fundamental form, Gauss and Weingarten equations.

**Essential Reading:**

**Suggested Readings:**

**MA 5112 DIFFERENTIAL TOPOLOGY**


**Essential Reading:**

**MA 5113 COMMUTATIVE ALGEBRA**

Dimension theory of affine algebras: Principal ideal theorem, Noether normalization lemma, dimension and transcendence degree, catenary property of affine rings, dimension and degree of the Hilbert polynomial of a graded ring, Nagata's altitude formula, Hilbert's Nullstellensatz, finiteness of integral closure.


**Essential Reading:**

**Suggested Readings:**

**MA 5114 HOMOTOPY THEORY** 3credits [3-0-0]

Brouwer Fixed point theorem, categories, functors, natural transformations, natural equivalence, Homotopy, convexity, contractibility, mapping cylinder and cones, paths and path connected spaces, Affine spaces, Affine maps, Homotopy as equivalence relation, Contractible Spaces, Homotopy of maps, Homotopy classes, Homotopically equivalent spaces with examples, Fundamental Groups, Induced maps and homomorphisms, Lifting property, Calculation of first homotopy groups, Function spaces, Group objects and cogroup objects, Loop space and suspension, Exact sequence of homotopy groups, Homotopy lifting property, Homotopy extension property, Fibrations and cofibrations, CW-complexes and their examples, attaching of maps, Homotopy groups of CW-complexes, The effect on the homotopy groups of a cellular extension, Spaces with prescribed homotopy groups, Weak homotopy equivalences and CW-approximation, Homotopy extension and classification theorems, Study of some cases where homotopy theory is applied in electrical engineering.

**Essential Reading:**

**MA 5115 RINGS AND MODULES** 3 credits [3-0-0]

Ring of continuous functions, matrix rings, polynomial rings, power series rings, Laurent rings, Boolean rings, Direct products, local rings, prime fields, Euclidean domains, PID, Unique factorization domains, Eisenstein’s criteria, modules, direct sum, free modules, quotient modules, simple modules, homomorphisms, module’s over PID’s, Artinian modules, Noetherian modules, Artian rings, Noetherian rings, Nil Radicals, Jacobson radicals.

**Essential Reading:**

**MA 5116 OPERATOR THEORY** 3 credits [3-0-0]

Essential Reading:

**MA 5117 Representation Theory** 3 credits [3-0-0]

Fundamentals of group representation, Abstract theory of representation of finite groups, Abelian groups, symmetric groups, Compact groups and semisimple groups, Peter-Weyel theorem. Haar measure.

Essential Reading:

Suggested Reading:

**MA 5118 LIE ALGEBRA** 3 credits [3-0-0]


Essential Reading:

Suggested Reading:

**MA 5119 DIFFERENTIABLE MANIFOLDS** 3 credits [3-0-0]


Essential Reading:

Suggested Reading:

**MA 5120 COMBINATORICS** 3 credits [3-0-0]

Graphs, trees, colourings of graphs and Ramsey’s theorem, addressing problem for graphs, principle of inclusion and exclusion, inversion formulae, permanents, elementary counting,
Stirling numbers, recursions and generating functions, partitions, (0,1) matrices, Latin squares, Hadamard matrices, 1 designs, codes and designs, strongly regular graphs and partial geometries, orthogonal latin squares, projective and combinatorial geometries, Gaussian numbers and q-analogues, Lattices and Möbius inversion, combinatorial designs and projective geometries.

**Essential Readings:**

**MA 5121 Distribution Theory**
3 credits [3-0-0]

Test functions and distribution, Test function spaces, Calculus with distributions, Localizations, support of distributions, Distribution as derivatives, Convolutions, Fourier Transformation, Tempered distributions, Paley-Wiener Theorem, Sobolov's lemma, Applications to differential equations, Fundamental soultions, Elliptic equations, Tauberian Theory, Wiener's Theorem,

**Essential Readings:**

**MA 5222 OPERATIONS RESEARCH**
3 credits [3-0-0]

*Nonlinear programming problem:* Kuhn-Tucker optimality conditions and convex programming, Kuhn-Tucker first order optimality conditions, Second order optimality conditions, Lagrange's method, convex programming problem, sufficiency of Kuhn-Tucker conditions, Lagrangian saddle-point and duality, duality of convex programs - quadratic programming (Wolfe's and Beale's methods)

*Network analysis:* Preliminaries, min cost flow problem, max flow problem, CPM/PERT, scheduling and sequencing.

*Queuing theory:* Introduction, components of a queuing problem, classification of queues, steady, transient and explosive states of a queue, Roles of Poisson process and exponential distribution in queuing theory, Queuing models, (M/M/1:∞/FIFO) model, Distribution of waiting time and time spent by an unit in the system, (M/M/1:N/FIFO) model, (M/M/c:∞/FIFO) model, (M/M/c:N/FIFO) model, (M/E/1:∞/FIFO) model, (M/E/1:1/FIFO) model, Examples of queuing models.

**Essential Reading:**

**Suggested Reading:**
MA 5326 Fuzzy Logic and Set Theory 3 credits [3-0-0]


Essential Reading:

MA 5327 Fractals 3 credits [3-0-0]

Fractal examples: Traidic Cantor dust, Sierpinski Gasket, A space of strings, Turfle graphics, Sets defined recursively, number system, metric topology, uniform convergence, Hausdorff metric, metrics for strings, topological dimension, small and large inductive dimension, two dimensional Euclidean space, other topological dimensions.

Essential Reading:

MA 5128 Graph Theory 3 credits [3-0-0]


Essential Reading:
2. B. Bollobas, Graph theory an introductory course, Springer-Verlag, 1979.

Suggested Reading:
1. N. Deo, Graph Theory with Applications to Engineering and Computer Science, PHI, 1974.


MA 5129 **CONVEX ANALYSIS AND OPTIMIZATION** 3 Credits [3-0-0]


**Essential Reading:**

**Suggested Reading:**

MA5331 **FOUNDATIONS OF MATHEMATICAL FINANCE** 3 Credits [3-0-0]

Fundamentals of the financial markets, meaning of notions like asset portfolio derivatives (example: Futures, options forwards etc.), Binomial asset pricing model under no arbitrage condition single-period model, multi-period model, risk-neutral probabilities, martingales in the discrete framework, risk-neutral valuation of European and American options under no arbitrage condition in the binomial framework, Introduction to continuous time models, Basic notions of probability theory on an infinite sample space, Change of measure and the Radon-Nikodym derivative, Random walk and Brownian motion, Ito integral and Ito formula Black-Scholes formula for pricing an European call option, Markowitz mean-variance portfolio optimization problem. Single-period and multi-period model, Capital asset pricing model, outlines of the measures of risk, Value at risk (VAR) and Conditional value at risk (CVAR).

**Essential Reading:**

**Suggested Reading:**

MA 5332 **FLUID DYNAMICS** 3 credits [3-0-0]

Review of gradient, divergence and curl. Elementary idea of tensors. Velocity of fluid, Streamlines and path lines, Steady and unsteady flows, Velocity potential, Vorticity vector, Conservation of mass, Equation of continuity. Equations of motion of a fluid, Pressure at a point in fluid at rest, Pressure at a point in a moving fluid, Euler’s equation of motion, Bernoulli’s equation. Singularities of flow, Source, Sink, Doublets, Rectilinear vortices. Complex variable method for two-dimensional problems, Complex potentials for various
Essential Reading:

Suggested Reading:

**MA 5333 FINITE DIFFERENCE METHODS** 3 credits [3-0-0]

*Iterative methods for linear systems:* Classical iterative methods (Jacobi, Gauss-Seidel and successive over relaxation (SOR) methods), Krylov subspace methods; GMRES, Conjugate-gradient, biconjugate-gradient (BiCG), BiCGStab methods, preconditioning techniques, parallel implementations.

*Finite difference method:* Explicit and implicit schemes, consistence, stability and convergence, Lax equivalence theorem, numerical solutions to elliptic, parabolic and hyperbolic partial differential equations.

**Essential Reading:**

**MA 5338 ADVANCED MATHEMATICAL METHODS** 3 credits [3-0-0]


**Essentials Reading:**

**Suggested Reading:**
MA 5140 GEOMETRY OF NORMED LINEAR SPACES 3 Credits [3-0-0]

Geometric form of Hahn-Banach theorem, w-w* topologies, Mazur’s, Alaoglu’s and Goldstine theorems, Reflexive spaces, James characterization of reflexivity, Strict convexity, Uniform convexity, Duality between strict convexity and smoothness, Differentiability of the norm, Drop theorem, Bishop-Phelps theorems, Krein-Milman theorem and Radon-Nikodym property, Asplund space, Fixed point theorems of Brouwer, Schauder and Tychonoff.

Essential Reading:

Suggested Reading:

MA 5142 TENSOR ANALYSIS 3 credits [3-0-0]

Tensor analysis: Transformation of coordinates, summation convention, Contravariant vectors, Invariants, Covariant vectors, Tensors, Christoffell 3-index symbols and their relations, Riemann symbols and the Riemann tensor, Ricci tensor, Quadratic differential forms, equivalence of symmetric quadratic differential forms, Covariant differentiation with respect to a tensor g, Introduction to a metric: Definition of a metric, N-tuply orthogonal systems of hypersurfaces in a V_n, Metric properties of a space V_n immersed in a V_m, Geodesics, Riemannian, Normal and geodesic coordinates, Geodesic form of the linear element, Finite equations of geodesics, Curvature of a curve, Parallel displacement and the Riemann tensor, Fields of parallel vectors, Associate directions, Curvature of V_n at point, Bianchi identity, theorem of Schur, Isometric correspondence of spaces of constant curvature, Conformal spaces, Spaces conformal to flat space, Orthogonal ennuples: Frenet formulas Principal directions determined by a symmetric covariant tensor of the second order, Ricci principal tensors, Condition that a congruence of an orthogonal ennuple be normal, N-tuply orthogonal systems of hypersurfaces, N-tuply orthogonal systems of hypersurfaces in a space conformal to a flat space, Congruence canonical with respect to a given congruence, Recent developments.

Essential Reading:

Suggested Reading:
Barry Spain, Tensor Calculus, Oliver and Boyd, 1965.

MA 5144 CATEGORY THEORY 3 credits [3-0-0]

Categories and Functors: The definition of a category, covariant and contravariant functors, natural transformations, natural equivalence, examples from different topics of engineering and sciences, duality principle, construct of small categories, Reflective subcategories, Coma category, Full and faithful functors, Limits and colimits: Products and coproducts, limits, colimits, equalizer, coequaliser, pullback, pushout, Universal and couniversal properties, Equivalence of equalizer and pullback in presence of products, Equivalence of coequalizer and pushout in presence coproducts, Limits in terms of products and equalizers, Limits in terms of products and pullback, Colimits in terms of coproducts and coequalizers, Colimits in terms of coproducts and pushout, Adjoint functors: Left adjoint, Right adjoint, Adjoint functor theorem, Preservation of limits by adjoint functors, Representable functors, Representing objects, Tensor products of categories.

Essential Reading:

MA 5148 WAVELET ANALYSIS 3 credits [3-0-0]
Review of Fourier series, Fourier transform on $L^1(\mathbb{R})$ and $L^2(\mathbb{R})$, basic properties and examples; Windowed Fourier Transform, Orthonormal basis generated by a single function, Balian-Low theorem, The Gabor transform, Wavelet Transform, Dyadic wavelets and examples, Spline wavelets, Daubechies wavelets, Multiresolution Analysis and construction of orthonormal wavelets, Properties of scaling functions, Some applications of wavelets.

Essential Reading:

Suggested Reading:

**MA 5250 PROBABILITY AND STATISTICS**

Algebra of sets, introduction to probability, random variables, probability distributions, moments, moment generating function, Markov and Chebyshev inequalities, special discrete and continuous distributions, function of a random variable, joint distributions, bivariate normal distribution, transformation of random vectors, central limit theorem, sampling distributions, point estimation, unbiasedness, consistency, method of moments and maximum likelihood estimation, confidence intervals for parameters in one sample and two sample problems from normal populations, testing of hypotheses, Neyman-Pearson lemma, tests for one sample and two sample problems for normal populations.

Essential Reading:

Suggested Readings:

**DISCRETE MATHEMATICS**

defined functions, Solving recurrence relations, Generating functions, Recursive algorithms. **Combinatorics and Discrete probability:** Fundamental counting principles, Permutations, derangements, Combinations, Permutations and combinations with repetitions, binomial theorem, generalized inclusion and exclusion principle, Discrete probability. **Relations:** Boolean matrices, Relations and digraphs, Computer representations of relations, Properties of relations, Operations on relations, connectivity relations, Equivalence relations, Partial and total orderings. **Graphs:** Computer representation of graphs, Paths, cycles and circuits, Eulerian and Hamiltonian graphs, Planner graphs, graph colouring. **Trees:** Spanning trees, Binary trees, and Binary search trees. **Boolean algebras and combinatorial circuits:** Boolean algebras, Boolean functions, Logic gates, combinatorial circuits.

**Essential Reading:**

**Suggested Readings:**

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**MA 5252 STATISTICAL INFERNECE** 3 credits [3-0-0]

Parametric models, parameters, random sample and its likelihood, statistic and its sampling distributions, problems of inference. Examples from standard discrete and continuous models such as Bernoulli, Binomial, Poisson, Negative Binomial, Normal, Exponential, Gamma, Weibull, Pareto etc. Concept of sufficiency, minimal sufficiency, Neyman factorization criterion, Fisher information, exponential families. Maximum likelihood estimators, method of moment estimators, percentile estimators, least squares estimators, minimum mean squares estimators, uniformly minimum variance unbiased estimators, Rao-Blackwell theorem, Cramer-Rao lower bond, different examples.

Statistical Hypotheses—simple and composite, statistical tests, critical regions, Type-I and Type-II errors, size and power of a test, Neyman Pearson lemma and its different applications. Most powerful test, uniformly most powerful test, unbiased test and uniformly most unbiased test. Likelihood ratio test. Interval estimation, confidence intervals, construction of confidence intervals, shortest expected length confidence interval, most accurate one sided confidence interval and its relation to UMP test.

**Essential Readings:**

**Suggested Readings:**
1. T. S. Ferguson, *Statistical Decision Theory*.

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**MA 5254 SAMPLING TECHNIQUES** 3 credits [3-0-0]

Basic concept of sample surveys: Census and sample surveys, Advantages and disadvantages, Probability and non-probability sampling, Sampling unit, Sampling frame, Sampling and non-sampling error, Simple random sampling and Stratified random sampling: Procedure for selecting a random sample, Estimation of population parameters, Estimation of population Proportion, Confidence limits, Estimation of sample size, Principle of stratification, Advantages of stratification, Estimation of population mean and variance,
Allocation of sample size in different strata, Relative precision of stratified random sampling over simple random sampling, Estimation of gain in precision due to stratification, Systematic random sampling: Sample selection procedure, Advantages and disadvantages, Estimation mean and its sampling variance, Comparison of simple random sampling with stratified random sampling in some specified populations, Cluster sampling: Equal cluster sampling, Estimator of mean and its variance, Relative efficiency of cluster sampling, Optimum cluster size, Cluster sampling for proportions.

Essential Reading:

Suggested Reading:

MA 5256 STATISTICAL DECISION THEORY 3 credits [3-0-0]

Games and statistical games, statistical decision problem, decision function, risk function, prior and posterior distribution, Bayes risk and Bayes rules, least favourable prior, minimaxity, admissibility and complete classes, admissibility of Bayes rules, existence of minimal complete class and Bayes rules, the supporting and separating hyperplane theorems, essential completeness of the class of non-randomized rules, minimax and complete class theorems, solving for minimax rules, essential completeness of class of rules based on sufficient statistics, continuity of risk functions, invariant decision problems, admissible and minimax invariant decision rules.

Essential Readings:
1. T. S. Ferguson, Statistical Decision Theory.

Suggested Reading:

MA 5158 ADVANCED NUMBER THEORY 3 Credits [3-0-0]


Essential Reading:

Suggested Reading:

MA 5360 FINITE ELEMENT METHODS 3 credits [3-0-0]

**Essential Readings:**

**Suggested Readings:**

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**PH1001: Physics -I (2-1-0)**

**Relativity:** Galilean relativity and Galilean transformation, Special relativity, Michelson Morley experiment and postulates of relativity, length contraction and time dilatation, twin paradox, Doppler effect, Lorentz transformation & velocity addition, relativistic momentum, mass-energy relation, brief introduction to general relativity.

**Quantum Mechanics:** INADEQUACIES IN CLASSICAL PHYSICS: Black body radiation, photoelectric effect, x-ray diffraction, Compton Effect, pair production, photon and gravity, Davisson-Germer experiment WAVE-PARTICLE DUALITY: Particle nature of wave, Wave nature of particle, de Broglie waves, group waves, phase velocity & group velocity, uncertainty principle and its application. WAVE FUNCTION: probability & wave equation, linearity and superposition of wave of wave functions, expectation values SCHRÖDINGER EQUATION: time dependent and time independent Schrödinger equation, eigenvalue & eigenfunctions, boundary conditions on wave function, APPLICATION OF SCHRÖDINGER EQUATION: Particle in a box, Finite potential Well.

**Essential Readings:**

**Supplementary Readings:**

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**PH1002: Physics -II (2-1-0)**

**Statistical Mechanics:** Statistical distributions, Maxwell-Boltzmann statistics, molecular energies in ideal gas, quantum statistics: B-E & F-D statistics, Rayleigh-Jeans formula, Planck's radiation law, specific heats of solids, free electrons in metals, electron-energy distribution,
Solid State Physics: Crystalline and amorphous solids, crystal structure, point defect, dislocations, ionic crystals, covalent crystals, van der Waals bond, metallic bond, band theory of solids, classification of solids based on band theory, impurity semiconductors, semiconductor devices (Junction diode, tunnel diode) photodiode: LED, semiconducting LASER and solar cell. Introduction to superconductivity, Meissner effect, Type I and type II superconductors, Bound electron pair (elements of BCS Theory) and high temperature superconductors.

Particle Physics: Fundamental interactions, leptons, hadrons, gluons, elementary particle quantum numbers, conservation laws.

Essential Readings:

Supplementary Readings:

PH2001: Waves and Oscillations (3-0-0)

Oscillations: Equilibrium, concept of potential well, small oscillations, linear and transverse oscillations of a mass between two springs, diatomic molecule, damped oscillations, critical damping, Q of an oscillator, forced oscillator with one degree of freedom, transient and steady state oscillations, resonance energy, low and high frequency responses, two dimensional oscillator, normal modes, longitudinal and transverse oscillation of coupled masses, energy transfer between modes, coupled pendulum. Fourier analysis: Fourier series and Fourier coefficients, exponential representation for harmonic oscillations, expression for Fourier coefficients, non-periodic disturbance, Fourier integral, Fourier transform wave-train of finite length, constancy of $\Delta x . \Delta k$ (uncertainty product), applications.

Waves: Classical wave equation, wave velocity, boundary conditions and normal modes, dispersion relations, dispersive waves, acoustic and optical modes, Waves in continuous media, speed of transverse waves on a uniform string, speed of longitudinal waves in a fluid, energy density and energy transmission in waves, typical measurements, dispersion in waves, group and phase velocity, superposition of waves, linear homogeneous equations and the superposition principle, interference in space and energy distribution, beats and tones, Doppler effect.

Essential Readings:

Supplementary Readings:
PH2002: Optics (3-0-0)

**Geometrical Optics:** Fermat’s principle of least action, reflection & refraction through spherical surfaces, thin lens and its focal length, Lateral magnification, Thick lenses, cardinal points, lenses separated by a finite distance and equivalent focal length, **Aberrations:** spherical aberrations, chromatic aberration, coma, astigmatism, curvature of the field, Huygens and Ramsden's eye pieces. **Coherence:** temporal coherence, line width, spatial coherence, principle of LASER and its types (Ruby, He-Ne & fiber LASER). **Interference:** Condition for interference, two beam interference by division of wave front, intensity distribution, Fresnel's biprism, displacement of fringes, two beam interference by division of amplitude, cosine law, Newton's rings experiment, Michelson Interferometer. multiple beam interference, Fabry-Perot interferometry, interference filters, **Diffraction:** Fraunhofer diffraction (single slit, double slit & N slit) Fresnel diffraction, Fresnel's half period zones, theory of zone plate, diffraction due to Circular aperture, opaque circular disc, straight edge, narrow wire, Rayleigh's criterion for resolution, resolving power of microscope, telescope, prism, grating. dispersive power of plane diffraction grating, introduction to holography **Polarization:** polarized and unpolarized light, Production of polarized light: (via reflection, double refraction & scattering), phenomena of double refraction, Malus Law, circularly and elliptically polarized light, quarter and half wave plates, Nicole prism. Fiber Optics: Propagation of light in fibers, single mode and multimode fibers, attenuation in optical fibers, step index fibers, parabolic- index fibers.

**Essential Readings:**


**Supplementary Readings:**


PH2003: Electricity & Magnetism (3-0-0)

**Electrostatics:** Electric field, divergence and curl of electrostatic field, electric potential, boundary conditions, work and energy in electrostatics, conductors, Laplace's equation(1D,2D,3D), boundary condition and uniqueness theorems, method of images, separation of variables, multipole expansion, Electric fields in Matter, **Magnetostatics:** The Lorentz force law, Biot-Savart law, magnetic Vector potential, boundary conditions, multipole expansion of vector potential, magnetization, magnetic materials, torque and forces on magnetic dipoles, field of a magnetized object, the auxiliary field H, boundary conditions, linear and non-linear media. **Electrodynamics:** Electromotive force, electro-magnetic induction, Maxwell's equations, boundary conditions.

**Essential Readings:**
PH2004: Introduction to Classical Mechanics (3-0-0)


Essential Readings:


Supplementary Readings:


PH2006: Analog & Digital Electronics (3-0-0)

Semiconductor devices; Bipolar Junction Transistors, Field Effect Transistors : JFET, MOSFET Basic differential amplifier circuit, negative feedback circuits, amplifier and oscillator circuits; operational amplifier, operational amplifier characteristics and applications, active filters and rectifier circuits, regulated power supplies;

Basic digital logic circuits, combinational logic circuit, half and full adder, sequential logic circuits, Multivibrators, flip-flops, counters, registers, multiplexures and demultiplexure, encoders and decoders, A/D and D/A conversion.

Essential Readings:


Supplementary Readings:

PH3001: Thermal Physics (3-0-0)

Concept of thermodynamic state, extensive and intensive variables, zeroth Law of thermodynamics, measurement of temperature, heat and work, internal energy function and the first law of thermodynamics, ideal gas and gas equations, ideal engine and Carnot cycle, concepts of entropy and temperature as conjugate pair of variables, second law of thermodynamics, entropy maximum and energy minimum principles, entropy, multiplicity and disorder, Maxwell’s demon, applications to pure substances, thermodynamic potentials, conditions of equilibrium, concepts of stability, Maxwell’s relations, metastable and unstable equilibrium, open systems, components and phases, Joule-Thomson expansion, Gibbs-Duhem relations, first order phase transitions and Clausius-Clapeyron equation, critical phenomena and higher order phase transition, applications for magnetic, dielectric and superconducting systems, heat engines and black body radiation, chemical equilibrium and ideal gas reactions, heterogeneous systems, thermodynamics of irreversible processes, entropy production, kinetic theory of gases, transport phenomena.

Essential Readings:

Supplementary Readings:
1. H.B. Callen, Thermodynamics and An Introduction to Thermostatics, John Wiley & Sons 2nd Ed.

PH3002: Introduction to Condensed Matter Physics (3-0-0)


Two Dimensional (2D) and Three Dimensional (3D) Lattices: Bravais Lattice, primitive vectors, Wigner-Seitz cell. Symmetries in crystal, space group and point groups. Simple cubic, face-centered cubic, body-centered cubic, hexagonal close-packed, diamond lattices. 14 Bravais lattices and seven crystal Systems.


Elastic and thermal properties of solids: Elastic strains and stress components, stiffness constants, bulk modulus, compressibility and elastic waves. Harmonic and adiabatic approximation. Vibrations of a monoatomic and di-atomic linear chain. Specific heat of
classical crystal, failure of classical theory. Quantum theory of lattice vibration, Einstein model, Debye model and Debye $T^3$ law. Thermal conductivity.

**Electronic properties of Metals**: Free electron theory; Drude model - DC & AC electrical conductivity, Hall effect and magnetoresistance, thermal conductivity and thermoelectric power. Sommerfeld theory; ground-state energy and bulk modulus, thermal properties of a free electron gas, theory of conduction, Wiedemann–Franz Law. Failures of the free electron model.

**Essential Readings:**
1. Introduction to Solid State Physics – Charles Kittel.

**Supplementary Readings:**

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**PH4001: Mathematical Physics (3-1-0)**


**Essential Readings:**

**Supplementary Readings:**
4. A. W. Joshi Matrix & Tensor in Physics
5. Tulsi Das , Satis. K. Sharma Mathematical methods in classical and quantum physics , University press
6. A. K. Ghatak, I. C Goyal , S. J. Chau Mathematical Physics , MacMillan India

**PH4002: Electrodynamics (3-1-0)**

Boundary value problems using Green's Functions, Electromagnetic waves in vacuum, Maxwell's stress tensor, momentum conservation, Poynting theorem, Lagrangian and
Hamiltonian formulation of electrodynamics, Gauge transformations, Coulomb gauge and Lorentz gauge, Electromagnetic waves in matter, reflection, transmission, Causality and Kramers-Kronig relations, negative-index materials, Cavities and Wave Guides. Radiation: Retarded Green's functions, Lienard-Wiechert potentials; dipole radiation, spectral resolution and angular distribution of radiation from a relativistic point charge; collision problems; bremsstrahlung & synchrotron radiation, radiation damping.

**Essential Readings:**

**Supplementary Readings:**

**Prerequisites:**  Electricity & Magnetism (PH2003) and Mathematical Physics (PH4001) courses

**PH4003: Classical Mechanics (3-1-0)**

**Rigid bodies:** Co-ordinates of rigid body, orthogonal transformation, properties of transformation matrix, Euler angles, Euler's theorem in motion of rigid body, finite and infinitesimal rotations, Rate of change of vectors, Coriolis effects. Angular momentum and kinetic energy of a rigid body, inertial tensor and principal axis transformation, Euler's equations, torque free motion of rigid body, heavy symmetrical top with one point fixed.

**Small oscillations:** Small oscillations, normal modes and frequencies.

**Canonical transformations:** Canonical transformations and some applications. Infinitesimal Canonical transformation, Integral invariant of Poincaré, Lagrange and Poisson brackets and their applications, Conservation theorems and angular momentum relation in Poisson brackets, Liouville's theorem.

**Hamilton-Jacobi theory:** Hamilton-Jacobi equation for Hamilton's principle and characteristics function and their application, Separation of variables, Action and angle variable and their applications.

**Special theory relativity:** Lorentz transformations, 4-vectors, Tensors, Transformation properties, Metric tensor, Raising and lowering of indices, Contraction, Symmetric and antisymmetric tensors, 4-dimensional velocity and acceleration, 4-momentum and 4-force, Covariant equations of motion, Relativistic kinematics, Lagrangian and Hamiltonian of a relativistic particle.

**Essential Readings:**

**Supplementary Readings:**

**Prerequisites:** Introduction to Classical Mechanics (PH2004).

**PH4004: Statistical Mechanics (3-1-0)**
Review of thermodynamics - Laws of thermodynamics, entropy, thermodynamic potentials & Maxwell's relations, chemical potential & phase equilibria; Equilibrium statistical mechanics-phase space, microstates, macrostates, micro-canonical, canonical & grand-canonical ensembles & and partition functions; Maxwell-Boltzmann, Fermi-Dirac & Bose-Einstein distributions, applications of statistical mechanics to ideal quantum gas, interacting systems, theories of phase transitions etc.

**Essential Readings:**


**Supplementary Readings:**


**Prerequisites:** Thermal Physics (PH3001).

**PH4005: Quantum Mechanics-I (3-1-0)**

**Formalism of quantum mechanics:** Hilbert space and wave function, Dirac notation, operators, operator representation in discrete and continuous basis, matrix representation, postulates of quantum mechanics: basic postulates of quantum mechanics, observables and operators, commutation relations and commutating observables, measurements in quantum mechanics, time evolution of system, symmetry and conservation laws, Schrödinger equation: time dependent and time independent Schroedinger equation, application to one dimensional harmonic oscillator. Schrödinger, Heisenberg and interaction pictures. Angular momentum: general formalism of angular momentum, Orbital angular momentum and its eigenfunctions, Spin angular momentum, experimental evidence of spin, Pauli matrices, application to three dimensional problems (Central potential),

**Essential Readings:**


**Supplementary Readings:**
4. L. Landau and E. M. Lifshitz, Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic), 3rd Ed

PH4006: Quantum Mechanics - II (3-1-0)


Essential Readings:

Supplementary Readings:
4. L. Landau and E. M. Lifshitz, Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic), 3rd Ed

Prerequisites: Quantum mechanics – I

PH5001: Nuclear & Particle Physics (3-1-0)


Standard model, fundamental forces, particle classifications, Spin and parity, Isospin, strangeness, hypercharge, baryon number, lepton number, Gellmann-Nishijima formula, Conservation laws, Quarks in hadrons. Meson and baryon octet, Parity violation, C, P and T invariance.

Essential Readings:


Semiconductors: General properties of homogeneous semiconductors and its band structure. Carrier concentration in thermal equilibrium, intrinsic and extrinsic semiconductors, impurity levels and its population in thermal equilibrium.

Magnetism in solids: Magnetic moment of an atom; orbital, spin and total magnetic moment, Hund’s rule. Larmor Diamagnetism, Van-Vleck Paramagnetism, Curie’s law for free ions and solids. Paramagnetism and diamagnetism of metals.


**Essential Readings:**
1) Solid State Physics – Ashcroft and Mermin.
2) Introduction to Solid State Physics – Charles Kittel.

**Supplementary Readings:**

**Prerequisites:** Quantum Mechanics-I (PH4005), Introduction to Condensed Matter Physics (PH3002) and Electrodynamics (PH4002)

**Essential Readings:**

**Supplementary Readings:**

**PH6001: Problems in Classical Physics (3-0-0)**

Lagrange's equations, velocity dependent potentials and dissipation functions, conservation theorems and symmetry properties, Hamilton's equation of motion, central force problem, scattering in central force field in center of mass frame and laboratory coordinates, rigid body rotations, Coriolis force, moment of inertia tensor, small oscillations, normal modes and frequencies, canonical transformation, Poisson brackets and their application, Hamilton-Jacobi theory and action angle variables, special theory of relativity, Lagrangian and Hamiltonian of a relativistic particle, 4-vectors, Relativistic kinematics.

**Essential Readings :**

**PH6002: Problems in Quantum Physics (3-0-0)**

Development of Quantum Mechanics, General Formalism of Quantum Mechanics, Operators, Postulates of Quantum Mechanics, observables and operators, commutation relations and commutating observables, measurements in quantum mechanics, time evolution of system, symmetry and conservation laws, Time dependent and time independent Schrödinger equation, Application to one and three dimensional problems, General formalism of angular momentum, Orbital and spin angular momentum and their eigenfunctions, Pauli matrices, Addition of two angular momentum, Calculation of Clebsch-Gordan coefficients, Coupling of orbital and spin angular momentum, Identical Particles,

**Essential Readings :**

**Supplementary Readings :**
1. L. Landau and E. M. Lifshitz, Course in theoretical physics vol.3-Quantum Mechanics (non-relativistic), 3rd Ed

**PH6003: Problems in Statistical Physics (3-0-0)**


**Essential Readings :**
1. H. B. Callen, Thermodynamics & an Introduction to Thermostatistics, John Wiley & Sons. 2nd Ed.

**PH6004: Problems in Mathematical Physics (3-0-0)**

**Solving problems in Mathematical Physics on the following Topics:**
1. Theory of analytic functions.
2. Linear vector space, matrix algebra, tensor & tensor calculus.
3. Function space, orthogonal polynomials, Fourier analysis and generalized functions.
Essential Readings:

Supplementary Readings:
5. A.W.Joshi Matrix & Tensor in Physics

PH6005: Experimental Techniques in Physics (3-0-0)

Measurements & error analysis: Uncertainty of measurements, Types of errors, Experimental uncertainty of single measurement and repeated measurements, Standard deviation, Propagation of error, Significant figures, Data Analysis.

Diffraction & Scattering techniques: Diffraction of x-rays in crystals via Laue, rotating crystal and powder method, reciprocal lattice, miller indices, atomic form factor, geometric structure factor, systematic absences and analysis of simple patterns, intensity of diffraction lines in a powder pattern, peak widths, determination of lattice parameters, crystallite size and strain, diffraction of electrons and neutrons, benefit of neutron diffraction. Theory and practice of light scattering, LASER light scattering, Dynamic and Static light scattering, small angle neutron and x-ray scattering.

Vacuum and Low Temperature: Need of vacuum, Characteristics of vacuum, Gas flow, Vacuum Pumps, Vacuum Gauges, Vacuum systems, Thin film deposition under vacuum, film thickness measurement, Use of vacuum in cryogenics, Physical properties at low temperature: Electrical conductivity, thermal conductivity, thermal expansion, Specific heat capacity, magnetic properties.

Thermal Analysis: Introductions, Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), differential scanning calorimetry (DSC) and their applications.

Microscopic & Spectroscopic Techniques: Optical Microscopy, Transmission electron microscopy (TEM), Scanning electron microscopy (SEM), Atomic force microscopy (AFM), Scanning tunneling microscopy (STM). Elemental analysis using EDX, XPS, SIMS, RBS, UV-Visible, Infrared and Raman spectroscopic Techniques.

Essential Reading:
(1) Ifan G Hughes and Thomas P A Hase, Measurements and Their Uncertainties: A Practical Guide to Modern Error Analysis, Oxford University Press (2010);
PH6006: Problems in Electrodynamics (3-0-0)

Review of Maxwell's equation, Electromagnetic waves in vacuum, Maxwell's stress tensor, momentum conservation, Poynting theorem, conservation of energy and momentum, Lagrangian and Hamiltonian formulation of electrodynamics, Gauge transformations, Coulomb gauge and Lorentz gauge, Electromagnetic waves in matter, reflection, transmission, Causality and Kramers-Kronig relations, negative-index materials, Cylindrical Cavities and Wave Guides; Modes in a Rectangular Wave Guide; Energy Flow and Attenuation in Wave Guides, Cavities, Dielectric Wave Guides.
Radiation: Introduction to Green's Functions, Retarded Green's functions, Lienard-Wiechert potentials; dipole radiation, spectral resolution and angular distribution of radiation from a relativistic point charge; collision problems; bremsstrahlung & synchrotron radiation.
Scattering of electromagnetic waves: Rayleigh and Thomson scattering, radiation damping. From Classical to Quantum ED: Approaches to quantization of EM fields; photons, Quantization of the free electromagnetic field.

Essential Readings:
D. J. Griffith, Introduction to Electrodynamics, Pearson Education. 4Th Ed., 2013.

Supplementary Readings:

PH6007: Problems in Condensed Matter Physics (3-0-0)

Bravais lattices; Reciprocal lattice, diffraction and the structure factor; Bonding of solids; Elastic properties, phonons, lattice specific heat; Free electron theory and electronic specific heat; Response and relaxation phenomena; Drude model of electrical and thermal conductivity; Hall effect and thermoelctric power; Diamagnetism, paramagnetism, and ferromagnetism; Electron motion in a periodic potential, band theory of metals, insulators
and semiconductors; Superconductivity, type – I and type - II superconductors, Josephson junctions; Defects and dislocations; Ordered phases of matter, translational and orientational order.

**Essential Readings:**
1) Solid State Physics – Ashcroft and Mermin.
2) Introduction to Solid State Physics – Charles Kittel.

**Supplementary Readings:**

**PH6111: Advanced Quantum Mechanics (3-0-0)**

Integral formulation of Quantum mechanics, Path Integral Integral, Relativistic wave equations, field quantization & particle processes, second quantization, interaction picture, S-matrix, many particle Green’s functions and diagrammatic methods, Feynman diagrams, many body physics, relativistic quantum mechanics of spin-1/2 particles, quantum theory of radiation, co-variant of perturbation theory, elements of quantum electrodynamics. Applications in condensed matter physics.

**Essential Readings:**

**Supplementary Readings:**

**Prerequisites:** Quantum mechanics courses.

**PH6112: Advanced Statistical Mechanics (3-0-0)**

Review of equilibrium statistical mechanics and its applications, theory of phase transition, critical phenomena, critical points and order parameter, thermodynamic properties and exponents, fluctuation of the order parameter, mean field theory .The renormalization group: the definition, fixed points and exponents, RG in selected models, perturbation expansion and dynamics. Ising Model and magnetism, correlation functions, superconductivity, superfluidity, Bose-Einstein condensation, fluctuation problems. Percolation problems; Kadona transformations, Ginzburg-Landau form. The correlation length and scaling
hypothesis, scale transformation and dimensional analysis; Non-equilibrium statistical mechanics, ergodic hypothesis and basic postulates, Langevin equations, Fokker-Planck equations, diffusion equation, entropy from trajectory of motion, instability of a trajectory.

**Essential Readings:**


**Supplementary Readings:**


**Prerequisites:** Statistical mechanics course.

**PH6113: Advanced Condensed Matter Physics (3-0-0)**

Second quantization, Fermi liquid, electron-electron interaction, electron-hole interaction in semiconductors, elementary excitation, electron-phonon interaction, polaron; Density functional theory and advanced band structure calculations, approximation in exchange potentials, molecular dynamics; Cooperative phenomena, paramagnetism, ferromagnetism, Ising model, superconductivity, BCS and Ginzburg-Landau theories, Bose-Einstein condensation, Dynamical mean field theory.

**Essential Readings:**


**Supplementary Readings:**


**Prerequisites:** Introduction to Condensed Matter Physics (PH3002), Condensed matter
physics (PH5003), Quantum Mechanics-I (PH4005), Quantum Mechanics-II (PH4006), Mathematical Methods in Physics (PH4001) courses / consent of the concerned faculty.

**PH6114: Non – linear dynamics, Chaos and its recent applications (3-0-0)**


**Essential Readings:**


**Supplementary Readings:**


**Prerequisites:** Good knowledge of Partial differential equations and algebra.

**PH6115:Synchronization and its recent applications in Chaotic systems (3-0-0)**

Synchronization in historical perspective. The basic notions: the self-sustained oscillators and its phase, self-sustained oscillators in nature, synchronization of a driven periodic oscillators, phase and frequency locking; Synchronization of higher order and Arnold tongues, synchronization of relaxor oscillators. Synchronization of two and many periodic oscillators, frequency locking, chains, lattices and oscillatory media; Synchronization in chaotic oscillators: Lorentz, Rossler, Marhieu oscillators; phase synchronization of chaotic oscillators, synchronization in the presence of noise, populations of globally coupled oscillators.

**Essential Readings:**

1. A. Pikovsky, M. Rosenblum and J. Kurths, *Synchronization: A Universal Concept in


Supplementary Readings:


Prerequisites: Good knowledge of differential equations and linear algebra.

PH6116: Nonlinear Optics (3-0-0)

Brief review of electromagnetic waves, Light propagation through anisotropic media, Overview of non-linear Optics, nonlinear optical susceptibility, origin of optical nonlinearities, symmetry properties of nonlinear susceptibility tensors, coupled-wave equations, second harmonic generation, sum and difference-frequency generation, phase-matching condition and techniques to achieve phase matching, parametric amplification, parametric fluorescence and oscillation, electro-optic effect, Kerr effect, Cross-Phase Modulation, self-focusing and self-phase modulation, optical solitons, Raman amplification, and acousto-optic effect, Nonlinear Schrödinger equation, modulation instabilities, optical solitons in fibers, photonic crystal fibers.

Essential Readings:

Supplementary Readings:


Prerequisites: Electrodynamics, Optics course, LASERS

PH6117: Introduction to Astrophysics

Introduction : Celestial sphere and co-ordinate systems, magnitude systems, determination of mass, luminosity, radius, temperature and distance of stars, stellar motion and stellar classification. Astronomical telescopes and detectors. Evolution of stars: star formation, Jean's criterion, HR diagram, end state of stars, Introduction to Compact Objects. Stellar structures: hydrostatic equilibrium, nuclear energy production and transport in stars, Solar
system. Structure and morphology of our galaxy Milky Way. General Theory of Relativity: Principle of equivalence, gravity and geometry, metric tensor and its properties, curved space time tensor calculus, Bianchi Identities, particle trajectories in gravitational field, Einstein’s field equations, Schwarchild metric, applications in astrophysics and observational tests. Large scale Structure and Cosmology: Hubble’s law, Friedmann Robertson-Walker Model, cosmological constants, the early universe, thermodynamics of early universe, nucleosynthesis, cosmic microwave background radiation, elementary ideas on structure formations, age of universe. big bang and steady state theory.

**Essential Readings:**
1. Astrophysics for Physicist, Arnab Rai Choudhuri
2. Physical Universe, Frank Shu.

**Supplementary Readings:**
1. A first course in general relativity, Bernard Schutz
2. Gravitation and cosmology, Steven Weinberg
3. Astrophysical techniques, C. R. Kitchin
4. Introductory astronomy and astrophysics, Michael Zeilik and Stephen A. Gregory
5. Theoretical astrophysics, T. Padmanabhan (Volume I, II, III)

**PH6120: Particle Physics (3-0-0)**


**Essential Readings:**

**Supplementary Readings:**

**Prerequisites:** Relativistic Quantum Mechanics / consent of the course teacher
PH6121: Quantum Field Theory (3-0-0)

Classical field theory; relativistic fields; identical bosons and quantum fields; Klein-Gordon propagator and relativistic causality; quantum electromagnetic fields and photons. Lorentz symmetry and spinor fields; Dirac equation and its solutions; second quantization of fermions and particle-hole formalism; quantum Dirac field; Weyl and Majorana spinor fields. Continuous symmetries and conserved currents; spontaneous symmetry breaking and Goldstone bosons; local (gauge) symmetry and QED; Higgs mechanism; non-abelian gauge symmetries and the Yang-Mills theory; discrete symmetries. Perturbation theory; correlation functions and Feynman diagrams; S-matrix and cross-sections; Feynman rules for fermions; Feynman rules for QED. Some elementary processes; radiative corrections; infrared and ultraviolet divergences; renormalization of fields and of the electric charge; Ward identities.

Essential Readings:

Supplementary Readings:

Prerequisites: Relativistic Quantum Mechanics / consent of the course teacher

PH6122: Computational Condensed Matter Physics (3-0-0)


Essential Readings:

Supplementary Readings:
2. R. E. Nalewajski, Density Functional Theory (Relativistic & Time Dependent), Springer Verlag, 1996.
Prerequisites: Quantum mechanics & condensed matter physics courses.

PH6231: X-rays and Nano Science (3-0-0)

Production and properties of X-rays. Introduction to Nanoscience, Roll of X-ray in Nanoscience. Real and reciprocal space, application of reciprocal space to diffraction, Ewald’s sphere, X-ray crystallography including space group and symmetries, scattering of X-ray by free and bound electrons, scattering by liquids; Introduction to Small Angle X-ray Scattering (SAXS), postulates of SAXS theory, Idea of different systems (ideal, non-ideal, monodisperse, polydisperse, dilute and dense systems). Overview of experimental SAXS system, Calculation of scattered intensity from a single particle & many particle systems, Refinement of SAXS data. Characterization of nano materials using SAXS data. General application of SAXS technique.

Essential Readings:

Supplementary Readings:

PH6232: Physics of Macromolecules (3-0-0)


Essential Readings:

Supplementary Readings:

Prerequisites: Basic Mathematics and statistics, basic thermodynamics.

PH6233: Advanced X-rays Structure Analysis (3-0-0)

Introduction to x-rays, Introduction to X-ray diffraction techniques, Qualitative and quantitative analysis of XRD data, prerequisites of Sample preparation for XRD data, Measurement of line intensities, Various factors affecting XRD intensities, Quantitative methods based on intensity ratios, The absorption diffraction method, Internal standard method, General RIR method, Normalized RIR method, Constrained XRD phase analysis, Detection limit issues Preliminary idea about XRF, PIXE, SAXS, GISAXS, EDX and their applications to characterize the materials with limitations of the techniques. X-ray spectroscopy and its application in characterization of materials. Advantages and disadvantages of the above mentioned techniques; Introduction to Medical application of X-rays and different equipments used for diagnosis purposes.

Essential Readings:

Supplementary Readings:

Prerequisites: Elementary knowledge on modern physics.

PH6234: LASER Physics (3-0-0)


Essential Readings:


**Supplementary Readings:**


**PH 6235: Fundamentals of Soft Matter (3-0-0)**


**Essential Readings:**


**Supplementary Readings:**


**Prerequisites:** Basic Concepts of Thermodynamics and Statistical Physics

**PH6341: Dielectric & Magnetic Properties of Materials (3-0-0)**

**Review of crystallography:** - Symmetry, point groups, Miller indices, Laue’s condition, Reciprocal lattice, Brillouin zones; **Magnetic Properties and magnetic materials:** - Van Vleck paramagnetism Quantum theory of paramagnetism and Ferromagnetism. Temperature dependence spontaneous magnetization, magnetic domain, hysteresis, Exchange interaction. Molecular field theory( Weiss law). Technological application of magnetic materials & multilayer in memory device, sensors, magnetic bubbles; **Phenomenological theories of magnetic order**- Interaction of atomic spins at large distance, molecular field theory, Spin waves, Ising model, Magnetic phase transition;
Dielectric material: Classical & Quantum, theory of electronic polarizability and ionic polarizability, spontaneous polarization, Hysteresis, Frequency dependent polarization, Piezoelectricity; An introduction to relaxor ferroelectricity. Perovskite crystal structure, Ferroelectric phases and domains, Curie Weiss behavior, Diffuse phase transition, Physics of Relaxor ferroelectricity, ABO3 relaxors, Application of ferroelectricity.

**Essential Readings:**

**Supplementary Readings:**

**Prerequisites:** 5th level condensed matter physics and quantum mechanics courses

**PH6342: Physics & Applications of Dielectric Materials (3-0-0)**


**Essential Readings:**

**Supplementary Readings:**

**Prerequisites:** Basic knowledge of Electrostatics, Magnetostatics & Dielectric Materials

**PH 6343: Mesoscopic Physics (3-0-0)**

Anderson Scaling theory. Localization weak localization and strong localization). Dephasing and renormalization.

**Different types of electrical transport mechanism**: Diffusive transport, ballistic transport, VRH, ES-VRH, Fluctuation Induced Transport mechanism (FIT), metal-insulator transition in transport behavior.


**Essential Readings:**


**PH6344: Physics of Ferroelectric and Multiferroic Materials (3-0-0)**

Fundamentals of dielectrics, Clausius-Mossotti relation, Dielectric dispersion and loss, Dielectric polarization and relaxation, Linear and non-linear dielectric, piezo-, pyro- and ferroelectric crystals; Classification and properties of selected ferroelectrics, Structural, dielectric, electrical, spectroscopic and optical properties of ferroelectrics; order-disorder and displacive type of phase transition, Phenomenological theory of Ferroelectrics: Dipole theory of phase transition, and thermodynamical theory of ferroelectrics: 1st order and 2nd order (Landau theory) phase transitions, critical phenomena, Lattice dynamics of Displacive phase transition, Quantum Ferroelectrics. Ferroelectric devices: pyroelectric detectors, transducers, computer memory and display devices, non-volatile memory devices. Magnetic terms and definitions, Classification, theory and properties of magnetic materials. Magnetization processes, Domain walls and contribution to the free energy, Fundamentals of Multiferroic and Magnetoelectric materials, Origin of polarizations and magnetization and the property of mutual exclusiveness, Types of multiferroics and mechanism, Experimental techniques for measurements. Some recent advances, Possible future applications of Multiferroic materials

**Essential Readings:**


**Supplementary Readings:**
2. S. Blundell; Magnetism in condensed matter, Oxford University Press, 2003

Prerequisites: Electrodynamics (PH-404), Condensed Matter Physics, (PH406)

PH6345: Physics of Quantum Electronic Devices (3-0-0)
Basics of quantum mechanics, origin of band, introduction and applications of quantum electronic devices, electrons in mesoscopic structures, quantum resistance, quantum capacitance, quantum interference, scattering at quantum levels, short channel MOSFET, split-gate transistor, electron wave transistor, electron spin transistor, single electron and atom transistors, molecular transistors, resonant tunneling, memory and logic devices, single electron inverters, quantum switches, sub-band quantum devices, quantum computers, different types of quantum bit.

Essential Readings:

Prerequisites: Quantum Mechanics (M. Sc. level)

PH6346 Physics of Semiconductors: From Bulk to Quantum Dots (3-0-0)
Crystal structure of Bulk semiconductors, theories of band structure, effective mass theory, k-p method etc. Band gap tailoring, doping with tri- and pentavalent elements, electron and holes, Fermi-Dirac statistics and electron & holes charge concentrations. Computational Method of band structure calculation, preparation of bulk and low dimensional semiconductors; Transport properties: Transport phenomena in bulk semiconductors: quantum mechanical theories of the interaction of photon with matter and first principle techniques for the calculation of transport properties, applied electric field and drift velocity, carrier mobility and ohm’s law, Diffusion and diffusion current equations, diffusion coefficient, Einstein relation, continuity equation, generation and recombination mechanism, minority carrier life time and diffusion length; Semiconductor heterostructure and their novel properties. Low dimensional semiconductors: two, one and zero dimensional semiconductors. Effect of quantum confinement. Semiconductor nano-structures and nanotubes: the band structure and ground state properties. Dilute magnetic semiconductors: magnetic properties of doped semiconductors with magnetic impurities.

Essential Readings:

**Supplementary Readings:**

**Prerequisites:** Quantum mechanics courses and basic knowledge of solid state physics

**PH6347: Physics of Thin film Technology (3-0-0)**

**Physical vapor deposition (PVD):** Physical fundamentals and technical aspects Theories of film growth and applications, Sputtering(RF &DC), Pulse laser deposition and Molecular beam epitaxy; **Chemical vapor deposition (CVD):** Physical fundamentals and technical aspects Theories of film growth and applications; Ferro Magnetic, dielectric and superconducting thin film and multilayer; Langmuir **Blodgett thin film:** Technical details, Isotherm, Applications to organic electronics sensors etc Self-assembly; **Sol-gel Spin coating:** Technical details-hydrodynamics of spin coating (Newtonian and non-Newtonian behavior), dip coating; **Thin film characterizing technique:** Surface Plasmon resonance spectroscopy, Ellipsometry, Atomic force Microscopy, and Tunneling electron microscopy, Transmission electron microscopy

**Essential Readings:**

**Supplementary Readings:**
1. R. Sahu, Physics of solid, nuclei and particle, Narosa publishing house, 2006.

**Prerequisites:** condensed matter physics and quantum mechanics courses.

**PH6350: Physics of Material Synthesis and Characterization (3-0-0)**

**Bulk Materials Synthesis Techniques:** Powders synthesis method; mechanical methods,hydrothermal synthesis of ceramic oxide powders, chemical methods, synthesis of

Essential Readings:

Supplementary Readings:

PH6351: Crystal Symmetry & Crystal Physics (3-0-0)

The development of structure and types of matter: liquid, amorphous and crystalline states. Crystal structure: lattice, basis, unit cell. Concepts of crystal symmetry: point symmetry, translational symmetry, Bravais lattices, crystal systems, point groups, space groups Examples of structures such as NaCl, CsCl, the diamond structure, cubic perovskite structure; Fundamental principle of x-ray diffraction, Scattering of x-ray by electron and atoms, Structure factor and Intensity. Typical crystal structure determinations from x-ray powder diffraction data. Determination of crystallite size and strain from x-ray diffraction pattern. : Crystal physics: Crystal symmetry and macroscopic physical properties, Symmetry of higher rank tensors and their applications to crystal properties: pyroelectricity, ferroelectricity, electrical conductivity, piezoelectricity, magnetic susceptibility and elasticity tensors.

Essential Readings:

Supplementary Readings:
**Prerequisites:** Basic Mathematical Physics mainly matrix and tensor analysis.

**PH6352: Semiconductor Devices Technology (3-0-0)**

Review of semiconductor device processing technologies, Clean room, Silicon wafer fabrication, Wafer cleaning, Oxidation techniques, Growth kinetics, Oxide growth measurements techniques, Defects in silicon and silicon dioxide, Diffusion, Ficks laws, Sheet resistivity and measurement of dopant profiles, Ion implantation, Mask fabrication, Pattern transfer, Lithography process: optical lithography, X-ray and e-beam lithography, Introduction to vacuum systems, Thin film growth (Evaporation, Sputtering, Chemical vapour deposition and Molecular beam epitaxy), Polysilicon, SiO$_2$, Si$_3$N$_4$ and silicide formation, Fabrication of ohmic and Schottky contacts, Lift-off techniques, Wet and plasma assisted etching techniques, Porous silicon, Encapsulation, Wire bonding, Packaging of semiconductor devices, Overview of process flow for IC technology, Future trends and challenges.

**Essential Readings:**

**Supplementary Readings:**
2. S. Franssila, Introduction to Microfabrication, Wiley, 2004

**Prerequisites:** First level Physics courses, Solid State Physics.

**PH6461: Physics of Microelectronic and Photonic Devices (3-0-0)**

The course introduces carrier transport in materials, physics of phenomena in semiconductors and optical fiber communications. This course provides basic idea to carry research in the area of semiconductors and photonics; Carrier Drift, Drift velocity, Carrier mobility, Carrier Diffusion, Generation and Recombination Process, Diffusion and diffusion current equations, Diffusion coefficient, Einstein relation, Continuity equation, Thermionic Process, Tunneling Process, High Field Effects; Thermal equilibrium condition, Depletion region, Depletion capacitance, Current voltage characteristics, Junction breakdown, Heterojunction, junction potential; Behaviour of charged particles in conducting, insulating and semiconductor materials - thin film phenomena - Transport properties of thin films - Epitaxial growth - Microelectronics - Lithography and etch techniques - Microelectronic devices for Magnetic, dielectric, conductive and optical memory applications; Radiative Transition and optical absorption, Light emitting Diode, Semiconductor Laser, Laser Diodes, Optical Modulators, optical fibers, couplers, electro-optic devices, magneto-optic devices, Photo detector, Solar cell.

**Essential Readings:**

Supplementary Readings:

Prerequisites: Knowledge in elementary solid state Physics and semiconductor properties.

PH6462: Super fluidity and Superconductivity (3-0-0)

Introduction to Superfluidity, 4He and 3He and their properties, Clausius-Clapeyron relation, Properties of solids at low temperature, Superdiamagnetism, Bose-Einstein Condensate, Supersolid, Superfluid film, gauge symmetry breaking, Thermodynamics of Superconductivity, Phenomenology of superconductivity, review of basic properties, thermodynamics of superconductors, Meissner effect, London equations, Cooper pairs, coherence length, Ginzburg-Landau theory, BCS theory, Josephson effect, SQUID, excitations and energy gap, magnetic properties of type-I and type-II superconductors, flux lattice, Quantum vortex; Introduction to high-temperature superconductors, Inhomogeneities, Superconducting order parameter fluctuation. Experimental Techniques for Low-Temperature Measurements, Material Properties and Superconductor Critical Current Testing.

Essential Readings:

Supplementary Readings:
3. Hagen Kleinert, Gauge Fields in Condensed Matter, Vol-I SUPERFLOW AND VORTEX LINES,
Prerequisites: knowledge in elementary solid state Physics and Statistical Mechanics.

PH6463: Physical Phenomena at Low Temperature (3-0-0)

Introduction with brief history, Need for low temperature, Techniques of attaining low temperature and its measurements, Ultra low temperatures (dilution refrigerator, adiabatic demagnetization, nuclear demagnetization and their measurements). Experimental determination of physical properties at low temperature (Electrical conductivity, thermal conductivity, Specific heat capacity, magnetic properties, thermolectric power, etc), Magnetic field in addition to low temperature, Effect of magnetic field on the physical properties, Sources of magnetic fields. Measurements involving high magnetic field (Electron spin resonance, Nuclear magnetic resonance, SQUID).

Essential Readings:
1. Frank Pobell, Matter and Methods at Low Temperatures (Springer, 2007)

Supplementary Readings:

Prerequisites: Elementary Condensed Matter Physics.

PH6464: Magnetism – Principles & Applications (3-0-0)


Essential Readings:
2. Stephen Blundell, Magnetism in Condensed Matter, Oxford University Press
3. Ralph Skomski, Simple Models of Magnetism, Oxford University Press
PH6465: Physics of Phase Transitions (3-0-0)

Phase, phase diagrams, phase transitions, Phase equilibrium, Thermodynamics and Statistical mechanics of phase transitions. Phase transitions in the Early Universe. Water-ice (liquid-solid), Dielectric, Magnetic and Superconductive transitions etc. Phase transformations in metals, alloys, fluids, Biopolymers (gelations). Liquid crystals and Superfluidity (He\textsuperscript{3}-He\textsuperscript{4}). Phase Transitions under Extreme Conditions and in large natural and technical systems. Formalism of first and second order phase transitions. Landau theory, Mean-Field theory. Recent scenario. Kinetic arrest and Glass transition. Transitions in Thin films, Microstructures and Nanostructures. Critical phenomena; a survey of some basic results.

Essential Readings:

Supplementary Readings:

Prerequisites: Fundamental level of Condensed Matter Physics, Thermal & statistical mechanics.

PH6466: Low Temperature Properties of Matter (3-0-0)


Essential Readings:
Supplementary Readings:
1. Franck Pobel; Matter and Methods at Low Temperatures; Springer, 2007
2. G. K. White & Philip J. Meeson; Experimental Techniques in Low Temperature Physics; Clarendon press, 2002
3. Jack W. Ekin; Experimental Techniques for Low-Temperature Measurements; Oxford University Press, 2006
4. Ralph Geoffrey Scurlock; Low Temperature Behaviour of Solids: An Introduction; Taylor & Francis, 1966
5. Randall Barron; Cryogenic Heat Transfer; Taylor & Francis, 1999

PH6467: Magnetism and Applied Magnetics (3-0-0)


Essential Readings:
3. B.D. Cullity, Introduction to Magnetic Materials, Addison-Wesley (1972)

Supplementary Readings:

PH1070: Physics Laboratory (0-0-3)

Demo Class:
Error & error analysis, graph drawing, least square fitting

List of Experiments
1. Familiarization of all Measuring Instruments.
2. Determination of g by Bar Pendulum.
3. Determination of Surface Tension by Capillary Rise Method.
5. To Find Unknown Low Resistance by Carey Foster Bridge.
7. To Compare Magnetic Moments by Using Deflection Magnetometer.
8. Diode Characteristics (Silicon, Germanium, Zener and LED Type).
9. To find Band Gap of an Intrinsic Semiconductor by Four Probe Method.
10. Optical Rotation by Half Shade Polarimeter.
11. Wavelength of Sodium Light by Diffraction Grating.
12. Wavelength of Sodium Light by Newton's Ring Method.
13. Determination of Thermal Conductivity of Bad Conductor by Lee's Disc Method.

Reference: Laboratory Manual.

PH2071: Electricity & Magnetism Lab. (0-0-3)

2. Study of Resonance & Damping Effect in LCR Circuit.
3. Study of Rise & Decay of Current in L-R Circuit With a Source of Constant EMF.
4. Study the Electro Magnetic Induction and Verification of Faraday’s Law.
9. To Study the Field Characteristics of Helmholtz Coil.
11. Study the Voltage Current Relationship in a R-L Circuit.

Reference: Laboratory Manual.

PH2072: Waves & Optics Lab. (0-0-3)

1. To Verify the Laws of Transverse Vibrations Using Sonometer.
2. Ultrasonic Interferometer Setup.
3. Determination of Velocity of Sound in Air.
4. To Measure the Thickness of Thin Foil with the Help of Air Wedge Set Up.
5. To Determine Refractive Index of Liquid Using LASER.
6. Verification of Malus Law
7. Determination of Wavelength of Sodium Light by Michelson's Interferometer
8. To Determine Wavelength of Sodium Light by Fresnel's Biprism
10. To Find the Resolving Power of Telescope.

Reference: Laboratory Manual

PH3071: General Properties of Matter & Thermal Physics Lab. (0-0-3)
1. Determination of the Spring Constant & Effective Mass of a Given Spiral Spring.
2. To Determine the Moment of Inertia & Radius of Gyration (Bifilar Suspension).
3. To Determine the Moment of Inertia of a Flywheel.
4. To Determine Poisson's Ratio for Rubber.
5. To Determine the Rigidity Modulus of the Material of the Wire (Torsional Pendulum).
6. To Determine the Young's Modulus of the Material of the Bar by Cantilever Bending.
7. To Determine the Modulus of Rigidity of Copper Wire Using Maxwell's Needle.
9. Measure the Thermal Conductivity of Copper Using Searle’s Method.
10. To Determine the Mechanical Equivalent of Heat by Callender and Barne’s Method
11. To Study the Voltage Response Curve of Various Thermocouples.

Reference: Laboratory Manual

PH4071: Modern Physics Lab. (0-0-3)

1. To Determine the Lande g Factor by ESR.
2. To Determine the Efficiency and Plateau Characteristics of a Geiger-Muller Counter.
3. To Find the Ionization Potential of Mercury Filled Vapour Lamp.
4. To Calculate the Planck’s Constant, Stopping Potential Using Light Emitting Diodes for Various Wavelength of Incident Light.
5. To Find the Discrete Energy of an Atom Using Frank Hertz Experiment.
6. To Determine the e/m Ratio by Using Helical Apparatus.
7. To Determine the e/m Ratio by Using Thomson Method.
8. To Determine the e/m Ratio Millikan Oil Drop Setup.

Reference: Laboratory Manual

PH4072: Condensed Matter Physics Lab. (0-0-3)

1. To Find The Magnetic Susceptibility Of Specimen by Gouy Balance Method.
2. To Find The Magnetic Susceptibility Of Solution by Quinke’s Tube Apparatus Setup.
3. To Find Activation Energy Of Thermistor
4. To Study The Variation Of Various Dielectric Parameters With Respect To Temperature And Frequency Of Dielectric Samples Using LR Meter.
5. To Determine The Hall Coefficient And Carrier Concentration Of A Semiconducting Sample At Different Temperatures.
6. To Study The Current Conduction Mechanism of a Metal Oxide Semiconductor Structure.
7. Contact Angle Measurement of Various Nanostructured Samples
8. To Determine The Sensitivity, Photo response Of Various Light Dependent Resistors (LDR)
9. Study Of Dispersion Relation Of Diatomic And Monoatomic Lattice (2 Set)
10. Magneto-Resistance Characteristics Of Semiconducting Sample

Reference: Laboratory Manual
PH4074: Computational Physics Lab. (0-0-3)

Programming & simulation with animation of following physical problems using Fortran, C++, Matlab & Python programming:

One, two and three dimensional motions, oscillations, Brownian motion, random walk problem, Monte Carlo simulation, nonlinear oscillations, bifurcation, wave motions, motion of wave packet, interference, diffraction, polarisation, Ising model, and use of available simulation packages for condensed matter physics problems.

Essential Readings:


Reference Readings:

1. Numeric Computing in Fortran by S.K Bose (Narosa, 2009)

2. Numeric method in electromagnetic fields by V.Subbarao (Narosa, 2011)

PH5071: Computational Astronomy Lab. (0-0-3)

1. Familiarity with Telescope.

2. Information about the astronomical objects from the spectra and image.

3. Identification of important lines in the spectra and determination of Doppler shift and radial velocity of an object.

4. Determination of ultraviolet extinction curve of a star using pair method.

5. Familiarity with Constellations using stellarium.


7. To measure the distance to the moon using parallax method.

8. To measure the distances of planets in our solar System.

9. To measure the proper motion of Barnard's star.

10. Study of solar spectrum and determination of element abundances.

11. Determination of distance and age of star cluster using color-magnitude diagram.

12. Determination of Hubble’s constant and the age of the Universe using spectra and image of a sample of galaxies.

Reference: Laboratory Manual

PH5072: Electronic Instrumentation Lab. (0-0-3)

1. Microprocessor based Physics experiments

2. AD/DA converter circuits for interfacing.

3. Creation of low temperature and its measurement

4. Measurement of Resistance of material at low temperature

5. Design of temperature sensor using commercial circuit resister and diodes.

6. Design of power supply using IC.

7. Design of power supply having + and –ve voltage supply to be used in OP-AMP
8. Design and fabrication of a constant current source.

Reference: Laboratory Manual

PH5074: Thin Film & Low Temp. Physics Lab. (0-0-3)

1. To Study Thin Film Deposition Techniques by PVD.
2. To Study Thin Film Deposition Techniques by RF Sputtering.
3. To Study Thin Film Deposition Techniques by Spin Coating.
4. To Study Thin Film Deposition Techniques by Dip Coating.
5. To Study the Vacuum Variation With Time by Rotary Pump.
6. To Find R Vs T Curve of Superconducting Sample.
7. To Study the Temperature Dependent Capacitance, Loss and Magneto-Capacitance of a Multiferroic Sample
8. To Study the Frequency Dependent Capacitance, Loss and Impedance of a Multiferroic Sample.
10. To Find Temperature Dependent Capacitance of a Sample at Low Temperature.

Reference: Laboratory Manual