ANURAG
Engineering Engineers

# ANURAG GROUP OF INSTITUTIONS

(AUTONOMOUS)

**(Formerly CVSR College of Engineering)**

Venkatapur, Ghatkesar, Hyderabad – 500 088.

www.anurag.edu.in

**B.Tech. Programs:**

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Civil Engineering
Computer Science and Engineering
Electrical and Electronics Engineering
Electronics and Communication Engineering
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Mechanical Engineering
Artificial Intelligence

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Pharma-D
Pharma-D (Post Baccalaureate)
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M.Pharm (Pharmaceutical Analysis & Quality Assurance)
M.Pharm (Industrial Pharmacy)

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M.Tech (Computer Science and Engineering)
M.Tech (Power Electronics & Electrical Drives)
M.Tech (Electrical Power Systems)
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M.Tech (VLSI System Design)
M.Tech (Embedded Systems)
M.Tech (Structural Engineering)

Master of Business Administration

# COURSE STRUCTURE AND DETAILED SYLLABUS

## CHEMICAL ENGINEERING

**R18 Regulations**

**FOR**
**B.TECH FOUR YEAR DEGREE COURSE**
(Applicable for the batches admitted from 2018-2019 onwards)


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# COURSE STRUCTURE AND DETAILED SYLLABUS

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## AUTONOMOUS

**II YEAR I SEMESTER** **COURSE STRUCTURE**

| Subject Code | Course Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| A53030 | ES | Engineering Mechanics | 3 | 0 | 0 | 3.0 |
| A53031 | BS | Engineering Chemistry – II | 2 | 0 | 0 | 2.0 |
| A53032 | PC | Fluid Mechanics | 3 | 0 | 0 | 3.0 |
| A53033 | PC | Material & Energy Balance Computations | 3 | 0 | 0 | 3.0 |
| A53034 | PC | Mechanical Unit Operations | 3 | 0 | 0 | 3.0 |
| A53035 | ES | Chemical Engineering Thermodynamics-I | 3 | 0 | 0 | 3.0 |
| A53213 | PC | Fluid Mechanics Lab | 0 | 0 | 3 | 1.5 |
| A53214 | PC | Mechanical Unit Operations Lab | 0 | 0 | 3 | 1.5 |
| A53007 | MC | Gender Sensitization | 3 | 0 | 0 | 0 |
| | | **Total** | **20** | **00** | **06** | **20.0** |

**II YEAR II SEMESTER** **COURSE STRUCTURE**

| Subject Code | Course Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| A54028 | PC | Process Heat Transfer | 3 | 0 | 0 | 3.0 |
| A54029 | BS | Probability and statistics | 3 | 0 | 0 | 3.0 |
| A54030 | PC | Chemical Engineering Thermodynamics-II | 3 | 0 | 0 | 3.0 |
| A54031 | ES | Material science and Engineering | 2 | 0 | 0 | 2.0 |
| A54032 | PC | Chemical Technology | 3 | 0 | 0 | 3.0 |
| A54033<br>A54034<br>A54035 | PE-I | • Technology of Pharmaceuticals and Fine Chemicals<br>• Environmental Biotechnology<br>• Water Conservation and Management | 3 | 0 | 0 | 3.0 |
| A54215 | PC | Process Heat Transfer Lab | 0 | 0 | 3 | 1.5 |
| A54216 | PC | Chemical Technology Lab | 0 | 0 | 3 | 1.5 |
| A54007 | MC | Environmental Studies | 3 | 0 | 0 | 0 |
| | | **Total** | **20** | **00** | **06** | **20.0** |

**III YEAR I SEMESTER** **COURSE STRUCTURE**

| Subject Code | Course Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| A55046 | PC | Chemical Reaction Engineering- I | 3 | 0 | 0 | 3.0 |
| A55047 | PC | Mass Transfer Operations-I | 3 | 0 | 0 | 3.0 |
| A55048<br>A55049<br>A55050 | PE-II | • Polymer Science and Engineering<br>• Corrosion Engineering<br>• Environmental Pollution and Control | 3 | 0 | 0 | 3.0 |
| A55051<br>A55052<br>A55053 | PE-III | • Industrial Safety and Hazard Management<br>• Petroleum and Petro Chemical Technology<br>• Pulp and Paper Technology | 3 | 0 | 0 | 3.0 |
| A55019 | HS | Managerial Economics and Financial Analysis | 3 | 0 | 0 | 3.0 |
| A55054 | PC | Numerical Methods in chemical Engineering | 2 | 0 | 0 | 2.0 |
| A55213 | PC | Numerical Methods in chemical Engineering Lab | 0 | 0 | 3 | 1.5 |
| A55214 | HS | Advanced English and Communication Lab | 0 | 0 | 3 | 1.5 |
| **Total** | | | **17** | **00** | **06** | **20.0** |

**III YEAR II SEMESTER** **COURSE STRUCTURE**

| Subject Code | Course Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| A56048 | PC | Chemical Reaction Engineering-II | 3 | 0 | 0 | 3.0 |
| A56049 | PC | Mass Transfer Operations –II | 3 | 0 | 0 | 3.0 |
| A56050 | PC | Plant Design & Economics | 2 | 0 | 0 | 2.0 |
| A56051<br>A56052<br>A56053 | PE-IV | • Nanoscience and Nano Technology<br>• Bio Chemical Engineering<br>• Fluidization Engineering | 3 | 0 | 0 | 3.0 |
| A56054<br>A56055<br>A56056 | PE-V | • Membrane Technology<br>• Optimization of chemical Processes<br>• Fertilizer Technology | 3 | 0 | 0 | 3.0 |
| A56001 | HS | Entrepreneurship Development | 3 | 0 | 0 | 3.0 |
| A56218 | PC | Chemical Reaction Engineering Lab | 0 | 0 | 3 | 1.5 |
| A56219 | PC | Mass Transfer Operations Lab | 0 | 0 | 3 | 1.5 |
| **Total** | | | **17** | **00** | **06** | **20.0** |

**IV YEAR I SEMESTER** **COURSE STRUCTURE**

| Subject Code | Course Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| A57063<br>A57030<br>A57012 | OE–I | • Renewable Energy Technology<br>• Intellectual Property Rights<br>• Disaster Preparedness and Planning | 3 | 0 | 0 | 3.0 |
| A57064 | PC | Process Instrumentation and Control | 3 | 0 | 0 | 3.0 |
| A57065 | PC | Process Modeling and simulation | 3 | 0 | 0 | 3.0 |
| A57066 | PC | Chemical process equipment design | 2 | 0 | 0 | 2.0 |
| A57067 | PC | Transport Phenomena | 3 | 0 | 0 | 3.0 |
| A57068<br>A57069<br>A57070 | PE-VI | Design and Analysis of Experiments<br>Computational Fluid Dynamics<br>Technology of fuel cells & batteries | 3 | 0 | 0 | 3.0 |
| A57221 | PC | Process Dynamics and Control Lab | 0 | 0 | 3 | 1.5 |
| A57222 | PC | Process Modeling& Simulation Lab | 0 | 0 | 3 | 1.5 |
| A57223 | | Mini Project | 0 | 0 | 4 | 2 |
| **Total** | | | **17** | **00** | **10** | **22** |

**IV YEAR II SEMESTER** **COURSE STRUCTURE**

| Subject Code | Course Code | Course Title | L | T | P | Credits |
|---|---|---|---|---|---|---|
| A58004<br>A58024<br>A58025 | OE-II | • Project Management<br>• Logical Reasoning, Verbal and Quantitative Ability<br>• Essential English and Employability Skills | 3 | 0 | 0 | 3.0 |
| A58026<br>A58010<br>A58020 | OE-III | • Machine Learning<br>• Internet of Things<br>• Python Programming | 3 | 0 | 0 | 3.0 |
| A58216 | -- | Technical Seminar | 0 | 0 | 6 | 2.0 |
| A58217 | -- | Comprehensive Viva Voce | 0 | 0 | 0 | 2.0 |
| A58218 | PW | Project Work | 0 | 0 | 15 | 10.0 |
| **Total** | | | **06** | **00** | **21** | **20.0** |

# ANURAG GROUP OF INSTITUTIONS
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**II B.Tech. – I Sem**

| L | T/P/D | C |
|---|---|---|
| 3 | -/-/- | 3 |

## ENGINEERING MECHANICS

**Course Objectives:**
The objectives of this course are to

1. Enable the students to do analysis of static objects by the concepts of force, moment, and mechanical equilibrium.
2. Develop the students' knowledge to solve various problems on friction.
3. Enable the students to find the centroid and center of gravity of a given section.
4. Develop the students knowledge to determine the area and mass moment of inertia of given section.
5. Enable the students to formulate a problem given from work-energy Principle.

**UNIT - I:**

**Introduction to Engineering Mechanics:**Basic concepts.
**System of Forces:** Coplanar, Concurrent Forces, Components in Space – Resultant- Moment of Forces and its Application; Couples and Resultant of Force System.
**Equilibrium of System of Forces:** Free body diagrams, Equations of Equilibrium of Coplanar Systems, Lame's Theorem.

**UNIT – II:**

**Friction***:* Basic concepts, Types of Friction, Laws of Friction, Static and Dynamic Friction, Motion of Bodies, Wedge friction, ladder Friction, screw friction, applications.

**UNIT - III:**

**Centroid:** Centroids of simple figures (from basic principles) Centroids of Composite Figures.
**Centre of Gravity:** CG of simple bodies (from basic principles), CG of composite bodies, Pappus theorem.

**UNIT- IV:**

**Area Moment of Inertia:** Definition - Polar Moment of Inertia, Transfer Theorem, MI of Composite Figures, Product of Inertia, Transfer Formula for Product of Inertia.
**Mass Moment of Inertia:** MI of Masses, Transfer Formula for MMI, MMI of composite bodies.

**UNIT - V:**

**Work – Energy Method:** Equations for Translation, Work-Energy Applications to Particle Motion. Connected System-Fixed Axis Rotation and Plane Motion. Impulse momentum method.

**Course Outcomes:**

After completion of the course, the students would be able to

1. Solve the resultant of forces which are acting on the systems and also able to apply the equilibrium conditions on a body.
2. Solve the problems based on friction.
3. Calculate the centroid and centre of gravity of composite sections.
4. Solve the area and mass moment of inertia of simple and composite sections.
5. Calculate the distance travelled and time required for the particle in case of connected systems.

**TEXT BOOKS:**

1) Singer's Engineering Mechanics by K. Vijaya Kumar Reddy and J. Suresh Kumar.
2) Engineering Mechanics by S.S.Bhavikatti, J.G.Rajasekharappa.
3) Engineering Mechanics by Timoshenko & Young.

**REFERENCE BOOKS:**

1) Engineering Mechanics by Meriam and Kraize
2) Engineering Mechanics by K.L.Kumar / Tata McGraw Hill.
3) Engineering Mechanics by A. K. Tayal.

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| II B.Tech. – I Sem | L | T/P/D | C |
|---|---|---|---|
| | 2 | -/-/- | 2 |

## ENGINEERING CHEMISTRY II

**PREREQUISITES:** Engineering Chemistry syllabus of I year

**Course Objectives:**

1. To bring understanding to the conception of chemistry and to become a perfect engineer.
2. To impart the basic knowledge of types of polymers and their applications in different walks of life.
3. To acquire the knowledge of IUPAC nomenclature of simple organic compounds to interpret the reactivity of organic molecules.
4. To acquire the skills relevant to various chromatography techniques and to apply them for medical and other fields.
5. To acquire the knowledge of green chemistry, dyes and fuels which are essential for the industry.

**UNIT-I Fundamentals of reaction mechanism**

Basic concepts of functional groups, electro negativity, dipole moment, Types of Organic reactions.Polar effects – Inductive effect, electromeric effect, mesomeric effect, Concept of reactive intermediates- carbanions, carbocations, carbenes and free radicals, Hyper conjugation, steric inhibition of resonance – examples.

**UNIT- II Polymers**

Polymerization Reactions – Basic concepts; Types of Polymerization – Addtion and Condensation Polymerizations, Plastics- Thermosetting and Thermoplastics – Differences, Molecular weights of polymer: Number average molecular weight, Weight average molecular weight, and Preparation, Properties and Engineering uses of the Following: Polyethylene, PMMA, Bakelite, Epoxy resins and Silicone Resins, Rubber - Processing of Natural Rubber, Vulcanization. Elastomers- Neoprene, Butyl rubber and Polyurethane Rubber.

**UNIT–III Fuels and Combustion**

Fuels, classification – (solid, liquid, gaseous). Calorific value of fuel –HCV, LCV. Solid fuels – coal – analysis – proximate and ultimate analysis and their significance. Determination of calorific value by Bomb Calorimeter. Liquid fuels – petroleum, refining of petroleum, cracking, knocking, synthetic petrol –Fischer- Tropsch's process; Gaseous fuels – natural gas, LPG, CNG: composition and uses. Analysis of flue gas by Orsat's method. Combustion –problems, determination of calorific value by Junker's gas calorimeter.

**UNIT– IV Chromatography**

Fundamentals of chromatographic techniques. Paper chromatography**:** Types of Paper chromatography, RF value. Thin Layer Chromatography: Stationary phase, mobile phase, sample application, development techniques – evaluation and documentation, advantages and disadvantages.
Gas Chromatography: Principle of Gas Chromatography, block diagram of gas chromatograph, Function of each component, stationary phase for column, mobile phase, chromatogram, applications of Gas Chromatography.

HPLC**:** Principles of high performance liquid chromatography, Block diagram of HPLC, Systems, functions of each component, stationary phases, eluting solvents, pumps, detectors, applications of HPLC.

**UNIT-V Green Chemistry**

Significance and determination of COD and BOD, Greenhouse effect and global warming, e-waste, radioactive pollution, Application of green chemistry and green technology.

**Dyes**

Colors and constitution, chromophore and auxochrome theory, modern theory of color, classification of dyes based on their structures and method of applications. Preparation, properties and applications of Malachite green and Bismark brown colors.

**Course Outcomes:**

**The course will enable the student to:**

1. Interpret the reactivity of organic molecules with concepts of functional groups**.**

2. Apply the knowledge of polymer properties to their structure and conformation.

3. Apply the knowledge of calorific value for the chemical analysis of various fuels.

4. Explain the concept of new analytical techniques that use chromatography principle.

5. Analyze the concept of green chemistry and industrial applications of dyes.

**TEXT BOOKS**:

1. Organic Chemistry- Reactions and Reagents- O.P. Agrawal– Krishna Prakashan media(P) Ltd.– 2009.

2. Organic Reactions and their Mechanisms, II Edition – P. S. Kalsi– New age International Publishers– 2000.

**REFERENCES:**

1. Organic Chemistry Vol- I-IL. Finar, V Edition– Pearson Publication.

2. Text book of Organic Chemistry – P.L. Soni– Sultan Chand & Sons, New Delhi– 2003.

3. Engineering Chemistry – Prasanta Rath and others–Cengage Publication, New Delhi – 2018.

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| II B.Tech. – I Sem | L | T/P/D | C |
|---|---|---|---|
| | 3 | -/-/- | 3 |

## FLUID MECHANICS

**Prerequisite**: Materials and Energy balance computations.

**COURSE OBJECTIVES:** After completion of the course, the students would be able

1. To understand the basic concepts of fluid mechanics and their applications in Chemical Engineering.
2. To develop relationships among process or system variables using dimensional analysis.
3. To illustrate the basic laws for systems like Continuity equation, Equation of Motion, Equation of Energy etc.
4. To evaluate the flow of incompressible and compressible fluids for laminar and turbulent flow.
5. To study and understand the transportation of fluids and pump systems along with flow meters.

**UNIT I: Introduction and Fluid Flow Phenomena**

Fluid statistics, Applications of fluid statistics, Properties of fluid, Classification of fluids, Newton's law of viscosity, Rheological classification of fluids, Newtonian and Non-Newtonian fluids, Turbulence, Reynolds number – its significance, Boundary layer theory, Manometers, Decanters, Centrifuge, Dimensional analysis, Buckingham π- theorem.

**UNIT II: Basic Laws for Systems**

Continuity equation, Momentum balance equation, Bernoulli's equation, Introduction to Navier-Stoke's and Euler's equations, macroscopic balance.

**UNIT III:**

**Incompressible flow:** In pipes and channels, laminar flow in pipes & channels, Hagen-Poiseuille's equation, turbulent flow in pipes & channels, Moody chart, Darcy Weisbach equation, Friction losses in expansion & contractions, Effects of fittings and valves.

**Compressible flow:** Processes of compressible flow, Isentropic flow through nozzles, Adiabatic frictional flow and isothermal frictional flow.

**UNIT IV: Flow past Immersed bodies**

Concept of Drag, Drag coefficient, drag coefficient with Reynolds number, flow through packed bed and fluidized bed, flow through bed of solids, motion of particles through the fluid, particle settling velocity.

**Fluidization:** Types of Fluidization, Minimum Fluidization velocity, Pneumatic conveying and other industrial uses.

**UNIT V: Transportation and metering of Fluids:** Pipes, fittings and valves, Classification of Pumps, Centrifugal pumps- Cavitation, NPSH, characteristic curves, positive displacement pumps, fans, blowers and compressors.

**Fluid Meters:** Volume flow measurement, full bore meters, area meters and local velocity measurement: Pitot tube, hot wire anemometers, mass flow meters.

**COURSE OUTCOMES:** After completion of the course, the students would be able to

1. Understand the fluid properties, their characteristics while static and during flow through ducts, pipes etc.
2. To develop the ability to formulate problems, identify the basic mechanisms.
3. To solve the problem by mathematical analysis or by application of experimental data.
4. To understand and use differential equations to determine pressure and velocity variations in internal and external flow.
5. Study and understand several machineries used to transport fluid and their performance.

**TEXT BOOKS:**

1. Unit Operations of Chemical Engineering, Mc-cabe, W.L. Smith, J.C. Harriott, Peter, Mc-graw Hill Higher Education Publication, New Delhi.

2. A Textbook of Fluid Mechanics and Hydraulic Machines, R K Bansal, 9$^{th}$ edition, Laxmi Publications, New Delhi, 2004.

**REFERENCES:**

1. Transport Processes and unit operations, Christie J. Geankoplis, PHI.

2. Richardson Chemical Engineering, Volume-1, M. Coulson, J.F. Richardson, with J.R. Backhurst and J.H. Harker, Coulson, 6$^{th}$ edition , Butterworth-Heinemann, 1999.

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**II B.Tech. – I Sem**

| L | T/P/D | C |
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| 3 | -/-/- | 3 |

## MATERIAL AND ENERGY BALANCE COMPUTATIONS

**PREREQUISITES:** First year physics, Chemistry & Mathematics

**COURSE OBJECTIVES:** After completion of the course, the students would be able

1. To given and apply principals of Material Energy Balance Computations in the project.
2. To understand and apply material and energy balance calculations in design.
3. Make Complex system simple by using principles of Material and Energy Balance Computations.
4. To learn modern estimation technique of Material and Energy Balance Computation to solve chemical problems.
5. To understand the aspects of recycle by –pass and purge and apply in chemical engineering in conservations.

**UNIT-I**

Stoichiometric relation: basis of calculations, methods of expressing compositions of mixtures and solutions, density and specific gravity, Baume and API gravity scales Behavior of ideal gases: applications of ideal gas law to gaseous mixtures, gases in chemical reactions, include combustion processes.

**UNIT-II**

Vapor pressure: Liquefaction and liquid state, vaporization, boiling Point, effect of temperature on vapor pressure, Antoine equation, Vapor pressure plots, estimation of critical properties, vapor pressure of immiscible liquids and ideal solutions, Raoult's law. Non-volatile solutes.

**UNIT-III**

Humidity and Saturation: Properties of air-water vapor mixtures, Absolute Humidity, molal humidity, Relative and percentage saturation, dew point, humid heat, wet bulb and dry bulb temperatures, use of humidity charts for engineering calculations.

**UNIT-IV**

Material balances: Tie substances, yield, conversion, limiting reactants, excess reactants, processes involving chemical reactions, Material balances with the help of stoichiometric

equations, Material balance calculations for processes involving recycle, bypass and purge Material balances involving drying, dissolution and crystallization.

**Unit-V**

Thermophysics: Energy, energy balances, heat capacity of gases, liquid and mixture solutions, Kopp's rule, latent heats, heat of fusion and Heat of vaporization, Trouton's rule, Kistiakowsky equation for non-Polar liquids, enthalpy and its evaluation Thermochemistry: Calculation and applications of heat of reaction, combustion, formation and neutralization, Kirchhoff's equation, enthalpy concentration change, calculation of theoretical actual flame temperature.

**COURSE OUTCOMES:** Student will able to learn

1. Fundamental laws of Stoichiometry.
2. Calculation of Vapor Pressures for Liquids using appropriate laws & critical Properties of ideal solution mixtures.
3. Calculation of Properties for Air-Water system using Humidification principles.
4. Material balances for Unit Operations with and without chemical reactions .
5. Energy balances for Unit Operations with and without chemical reactions.

**TEXT BOOKS:**

1. Chemical Process Principles, Part-I, Material and Energy Balance by Hougen O A, Watson K.M and Ragatz R. A. John Wiley and sons, New York, 1963, 2nd Ed.

**REFERENCES:**

1. Basic Principles and Calculation in Chemical Engineering by D. H. Himmelblau, 5th Ed. PHI, 2001
2. Stoichiometry by B.I, Bhatt and S.M. Vora (3rd Ed.) Tata Mc Graw Hill Publishing Company, Ltd. New Delhi (1996)

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| II B.Tech. – I Sem | L | T/P/D | C |
|---|---|---|---|
| | 3 | -/-/- | 3 |

## MECHANICAL UNIT OPERATIONS

**PREREQUISITES:** First year Mathematics I & II

**COURSE OBJECTIVES:** By studying this subject students will learn about

1. Characterization of solids
2. Size reduction equipment's
3. Transportation of solid particulate mass
4. Techniques of solid – fluid separation
5. Agitation and mixing of liquids

**UNIT-I**

Properties, handling and mixing of particulate solids: Characterization of solid particles, properties of particulate masses, storage and mixing of solids, types of mixers, mixers for cohesive solids, mixers for free flowing solids. Transportation of solid particulate mass, belt, screw, apron conveyers, bucket elevators, pneumatic conveying

**UNIT-II**

Size reduction: Principles of comminution, size reduction equipment crushers, grinders, ultra-fine grinders, cutting machines, Equipment operation. Screening, Industrial screening equipments

**UNIT–III**

Filtration, cake filters, centrifugal filters, Principles of cake filtration. Clarifying filters, liquid clarification, gas cleaning, and principles of clarification.

Cross flow filtration, types of membranes

**UNIT-IV**

Separations based on motion of particles through fluids, gravity settling processes and centrifugal settling processes, float and sink method, differential settling, coagulation, Flotation-separation of ores, flotation agents

**UNIT –V**

Agitation and mixing of liquids: Agitation of liquids, circulation velocities, power consumption in agitated vessels. Blending and mixing of liquids, suspension of solid particles, dispersion operations.

Crystallization: crystal geometry, crystal growth.

**COURSE OUTCOMES:**

By the end of this course, the student will be able to:

1. Understand about different types of size reduction processes
2. Understand and apply the basic methods of characterization of particles and bulk solids, e.g. average particle size, settling velocity;
3. Describe the operation of filter processes and types of filters used to perform solid-liquid separations, and calculate their power requirement
4. Design a mixed tank, calculate its power requirements and scale-up the design
5. Describe the Transportation of solids

**TEXT BOOKS:**

1. Unit Operations in Chemical Engineering by W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill 5th ed. 1993.

**REFERENCES:**

1. Chemical engineers hand book, J.H. Perry, 7th ed. Mc Graw Hill.
2. Badger and Bencharo, "Introduction to Chemical Engineering". TMH,Narayanan C.M.& Bhattacharya B.C. "Mechanical opeartions for chemical engineers", Khanna

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**II B.Tech. – I Sem**

| L | T/P/D | C |
|---|---|---|
| 3 | -/-/- | 3 |

## CHEMICAL ENGINEERING THERMODYNAMICS-I

**PREREQUISITES:** Chemical Process Calculations & First year Physics

**COURSE OBJECTIVES**

1. Explain the concepts of internal energy, heat, and work and energy conversion.
2. Use equations of state, correlations and tables for real fluids.
3. Reiterate the laws of thermodynamics, and understand the practical implications of these laws in engineering design.
4. Calculate the efficiencies of expansion and compression for flow processes
5. Analyze processes involving power production, refrigeration, and liquefaction.

**UNIT I**

**Introduction**: The scope of thermodynamics, Dimensions and units, temperature and Zeroth Law of Thermodynamics, Force, volume, pressure, work, heat, Energy classifications- energy in transit, point and path properties, thermodynamic state and state functions, reversible and irreversible processes, equilibrium, The phase rule.

**UNIT-II**

**The first law and other basic concepts:** Joules Experiments; The first law of thermodynamics and Internal Energy; Energy balance for closed systems; enthalpy; constant-V and constant- P processes; heat capacity; Mass and energy balance for open systems.

**Volumetric properties of pure fluids:** The PVT behavior of pure substances; virial equations of state; the ideal gas; applications of the virial equations; Cubic equations of state; generalized correlations for gases; generalized correlations for liquids.

**UNIT-III**

**The second law of thermodynamics:** Statements of the second law; heat engines; thermodynamic temperatures scales - thermodynamic temperature and the ideal gas scale; Entropy; Entropy changes of an ideal gas; mathematical statement of the second law; Entropy balance for open systems; calculation of ideal work and lost work; the third law of thermodynamics; entropy from the microscopic view point.

**UNIT-IV**

**Thermodynamic properties of fluids:** Property relations for homogeneous phases; residual properties; two phase systems; thermodynamic diagrams; tables of thermodynamic properties; generalized property correlation for gases.

Application of thermodynamics to flow processes: Duct flow of compressible fluids - pipe flow, nozzles, throttling process; turbines; compression processes – compressors and pumps;

**UNIT-V**

**Production of power from heat:** The steam power plant-the Rankine cycle; Internal combustion Engines- the otto engine, the diesel engine, the gas-turbine engine; Jet engines.

**Refrigeration and liquefaction:** The Carnot refrigerator; the vapor compression cycle; the comparison of refrigeration cycles; the choice of refrigerant; absorption refrigeration; the heat pump; liquefaction processes.

**COURSE OUTCOMES**

**Students will be able to:**

1. Identify, formulate and solve engineering problems in classical thermodynamics.
2. Apply mass and energy balances to closed and open systems and study the PVT behavior of pure substances.
3. Apply the laws of thermodynamics and estimate the heat and work requirements for Industrial Processes.
4. Evaluate thermodynamic properties of ideal and real mixtures and the efficiency of flow processes.
5. Analyze liquefaction, refrigeration and different power cycles.

**TEXT BOOKS:**

1. Smith , J.M., Van Ness, H.C and Abbott, M.M., " Introduction to Chemical Engineering Thermodynamics ", 7th ed, Tata McGraw Hill., 2005.

**REFERENCES:**

1. M J Moran, H P Shapiro, D Boettner and M B Bailey, Principles of engineering Thermodynamics, 8th Ed, Wiley.
2. Kyle, B.G., “Chemical and Process Thermodynamics”, 3rd ed. “ Pearson, Prentice Hall of India Pvt. Ltd., 1999.
3. K.V.Narayanan, Chemical Engineering Thermodynamics, Prentice Hall of India Pvt Ltd., 2009
4. Hougen, O.A., Watson, K.M., and Ragatz, R.A., “Chemical Process Principles, Part II ", Thermodynamics, John Wiley, 1970.
5. Dodge, B.F., " Chemical Engineering Thermodynamics ", McGraw-Hill, 1960

# ANURAG GROUP OF INSTITUTIONS
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| II B.Tech. – I Sem | L | T/P/D | C |
|---|---|---|---|
| | -- | -/3/- | 1.5 |

## FLUID MECHANICS LAB

**COURSE OBJECTIVES: Students will be able**

1. To gain practical knowledge on the measurement of fluid flow and their characteristics at different operating conditions.

2. To determine experimentally the flow characteristics of fluids and also to determine the efficiency of the flow measuring devices and fluid transport machineries.

3. To investigate the discharge coefficients for orifice and venturi meters.

4. To examine the type and nature of flow using Reynold's apparatus.

5. To evaluate the friction losses in smooth and bend pipes.

(Atleast **TEN** experiments out of the following Twelve experiments should be performed).

1. Experiments on Reynolds Apparatus for determination of flow regime.

2. Determination of coefficient of discharge for orifice meter.

3. Determination of coefficient of discharge for Venturi meter.

4. Determination of coefficient of discharge for V-notch.

5. Determination of efficiency of a centrifugal pump.

6. Calibration of Rotameter.

7. Frictional losses in straight pipes and construction of fanning friction factor vs Reynolds number plot.

8. Frictional losses in bend pipes and construction of fanning friction factor vs Reynolds number plot.

9. Determine absolute viscosity of glycerol-water mixture.

10. To determine the pressure drop across the packed column.

11. Experiment on fluidization techniques and determination of

(a) Minimum fluidization velocity;

(b) Pressure drop profile

12. Experiment is to verify Bernoulli's theorem.

**LIST OF EQUIPMENTS/MACHINES REQUIRED:**

1. Reynolds apparatus
2. Orifice meter
3. Venturi meter
4. V-notch apparatus
5. Centrifugal pump
6. Rotameter
7. Set of straight pipes
8. Set of fittings in pipes
9. Cannon viscometer
10. Packed column apparatus
11. Fluidized column
12. Bernoulli's apparatus

**COURSE OUTCOMES**

**Students will be able to:**

1. Understand concepts on nature of fluids, pressure concepts and measurement of pressure by various experimental methods and by mathematical relations and enhancement of problem solving skills.

2. Understand clear concepts on flow of incompressible fluids in conduits and thin layers and friction factor variations with velocity and friction losses using Bernoulli's equations which will be demonstrated experimentally.

3. Determine velocity using Cannon Fenske viscometer.

4. Determine terminal velocity of particles in a packed column.

5. Understand principles and working of various types of pumps, transportation and metering of fluids using various experimental techniques.

**TEXTBOOK:**

1. "Unit Operations in Chemical Engineering", W.L. Mccabe and J.C. Smith, 4th Edition, McGraw Hill Publishing Co., 1985.

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| **II B.Tech. – I Sem** | **L** | **T/P/D** | **C** |
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## MECHANICAL UNIT OPERATIONS LAB

**COURSE OBJECTIVE:** Students will able to

1. Develop a sound working knowledge on different types of crushing equipment's
2. Explain the laws of crushing using any size reduction equipment
3. Explain solid liquid separations
4. Explain particle sizes
5. Determine the density of materials

(At least **Ten** experiments out of the following twelve experiments should be performed)

**List of Experiments:**

**1.** To determine the time of grinding in a ball mill for producing a product with 80 % passing a given screen.

Major equipment - Ball mill Apparatus, Sieve shaker, Different sizes of sieves, Weighing balance.

**2.** To verify the laws of crushing using any size reduction equipment like crushing rolls or vibrating mills and to find out the working index of the material.

Major equipment – Jaw Crusher, Sieve shaker, Different sizes of sieves, Weighing

Balance, Energy meter

**3.** To find the effectiveness of hand screening of a given sample by a given screen.

Major equipment - Vibrating Sieve shaker, Different sizes of sieves, Weighing

Balance

**4.** To separate a mixture of oil into two fractions using froth flotation technique.

Major equipment - Froth flotation cell

**5.** To obtain batch sedimentation data and to calculate the minimum thickener area under given conditions.

Major equipment- Sedimentation apparatus

**6.** To determine the specific cake resistance and filter medium resistance of slurry in plate

and frame filter press.

Major equipment - Plate and Frame filter press.

**7.** Verification of Stoke's law.

Major equipment – Stoke's law apparatus.

**8.** To take a representative sample from a bulk by two methods, Cone& Quartering and

to find out the average size {volume-surface mean diameter} of the samples.

**9**. To find the size analysis of a given fine sample using beaker decantation method.

**10.** To verify the laws of crushing using any size reduction equipment like roll crusher find out the working index of the material.

– Roll Crusher, Sieve shaker, Different sizes of sieves, Weighing Balance, Energy meter.

**11.** To separate a mixture of particles by jigging

Major Equipment – Mineral Jig

12. To analyze a given powder for its particle size distribution. / Cumulative and Differential methods of particle size distributions

**13**. To calculate separation efficiency of particles in a mixture using cyclone separator.

Major Equipment – Cyclone separator

**14**. To determine the bulk, tapped and true density along with the flow ability and porosity of a given fine sample

**COURSE OUTCOME:**

students will able to

1. Gain the practical knowledge and hands on various separation techniques like filtration, sedimentation, screening, froth flotation, and beaker decantation and size reduction operations.

2. Explain the energy for different size reduction equipment's.

3. Determine the efficiency of screens

4. Determine the viscosity of fluid using settling velocity method

**5.** Determine the avg.Particle sizes

**TEXT BOOK:**

1. Unit Operations in Chemical Engineering by W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill 5th ed. 1993.

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| II B.Tech. – I Sem | L | T/P/D | C |
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## GENDER SENSITIZATION

**COURSE OBJECTIVES:** Students will able

1. To develop students sensibility with regard to issue of gender in contemporary India.
2. To provide a critical perceptive on the socialization of men and women
3. To introduce students to information about some key biological aspects of genders.
4. To expose the students to debates on the politics and economics of the work.
5. To help students reflect critically on gender violence. Expose students to more egalitarian interactions between men and women.

**UNIT 1**

Understanding Gender:
Gender: why should we study it? (Towards a world of equals: (Unit-1)
Socialization: Making women, making men towards a world of equals: (Unit-2)
Introduction. Preparing for womanhood. Growing up male. First lessons in caste. Different masculinities.
Just relationships: Being together equals (towards a world of equals: (Unit-3).
Mary kom and onler .love and acid just do not mix. Love letters mothers and fathers. Further reading: Rosa parks-the brave heart.

**UNIT-II**

Gender and Biology:
Missing women: sex selection and its consequences towards a world of equals: (Unit-4)
Declining sex ratio. Demographic consequences. Gender spectrum: Beyond the (towards a world of equals: (Unit-10)
Too or many? Struggles with discrimination .additional reading: our bodies our health (towards a world of equals: (Unit-13)

**UNIT-III**

Gender and Labor: House work: the invisible labor (towards a world of equals: (Unit-3)
"My mother doesn't work ", "share the load".
Women's work: its politics and economics (towards a world of equals: (Unit-7)
Fact and Fiction: unrecognized and unaccounted work. Further reading: wages and conditions of work.

**UNIT-IV**

Issues of the violence: Sexual harassment: say no! (Towards a world of equals: (Unit-6), sexual; harassment, not eveteasing-couping with every day harassment-Further reading: "chupulu"
Domestic violence: speaking out (towards a world of equals: (Unit-8)
Is home a safe place? When women unite [film].rebuilding lives. Further reading: New forums for justice.
Thinking for sexual violence (towards a world of equals: (Unit-11)
Blaming the victim-I fought for my life ….." Further reading: the caste face of violence.

**UNIT-V**

Gender Studies:

Knowledge: through the lens of gender (towards a world of equals: (Unit-5).point of view. Gender and the structure of knowledge: Further reading: unacknowledged women artists of Telangana.

Whose history? Questions for historians and others (towards a world of equals: (Unit-9)

Reclaiming a past. Writing other histories .Further reading: missing pages from modern Telangana History.

Essential Reading: All the units in the textbook, "Towards a world of equals: A bilingual Textbook on Gender" written by A.Suneetha, Uma Bhrugubanda, Duggirala Vasantha, Ramamelkote, Vasuda Nagaraj, Asman Raseed, Gogu Shyamala, Deepa Srinivas, Susietharu

Note: Since it is interdisciplinary course resource persons can be drawn in the field of English literature or sociology or political science or any other qualified faculty who has expertise in this field

References Books

1. Sen, Amartya. "More than one million women are missing". New York Review of Books 37, 20 (20 December 1990). Print. 'We Were Making History'.. Life Stories of Women in the Telangana people's Struggle, New Delhi: Kali for Women, 1989.
2. Tripti Lahiri, By the Numbers: Where Indian Women Work." Women's Studies Journal (14 november 2012). Available online at: http:// blogs.wsj.com/India real time/2012/11/14/by – the-numbers-where-Indian-women-work/>
3. K. satyanarana and Susie Tharu (Ed) Steel Nibs are Sprouting: New Dalit Writing From South India, Dossier 2: Telugu and Kannada http://harpercollins.co.in/BookDetail.asp?Book Code=3732
4. Vimala."Vantillu (the kitchen)" . Women Writing in India: 600 BC to the Present. Volume II: The 20th Centuary. Ed. Susie Tharu and K.Lalita. Delhi: Oxford University Press, 1995, 599-601
5. Virginia Woolf. A Room of One's Own. Oxford:Black Swan, 1992
6. K.Kapadia. The violence of Development: The politics of Identity, Gender and Social Inequalities in India. London: Zed Books, 2002

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**II B.Tech. – II Sem**

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## PROCESS HEAT TRANSFER

**PREREQUISITE:** Chemical Process Calculations, First year Physics

**COURSE OBJECTIVES:**

1. To learn about the basic concepts and laws of the three modes of heat transfer
2. To Determine heat transfer coefficients for forced and natural convection & concept of fouling
3. To analyze the heat transfer processes involved in boiling and condensation
4. To perform basic calculations of common heat exchangers and evaporators
5. To Analyze the heat radiation in detail

**UNIT I:**

**Introduction**

Nature of heat flow, conduction, convection, natural and forced convection, radiation.

**Heat transfer by conduction in Solids**

Fourier's law , thermal conductivity, steady state conduction in plane wall & composite walls, compound resistances in series, heat flow through a cylinder, conduction in spheres, thermal contact resistance, plane wall: variable conductivity

**Unsteady state heat conduction**

Equation for one-dimensional conduction, Semi-infinite solid, finite solid.

**Unit- II:**

**Principles of heat flow in fluids**

Typical heat exchange equipment, countercurrent and parallel current flows, energy balances, rate of heat transfer, overall heat transfer coefficient, electrical analogy, critical radius of insulation, logarithmic mean temperature difference, variable overall coefficient, multi-pass exchangers, individual heat transfer coefficients, resistance form of overall coefficient, fouling factors, classification of individual heat transfer

coefficients, magnitudes of heat transfer coefficients, effective coefficients for unsteady-state heat transfer.

**Natural convection**

Natural convection to air from vertical shapes and horizontal planes, effect of natural convection in laminar-flow heat transfer, free convection in enclosed spaces, mixed free & forced convection.

**Unit- III:**

**Heat Transfer to Fluids without Phase change**

Regimes of heat transfer in fluids, thermal boundary layer, heat transfer by forced convection in laminar flow, heat transfer by forced convection in turbulent flow, the transfer of heat by turbulent eddies and analogy between transfer of momentum and heat, heat transfer to liquid metals, heating and cooling of fluids in forced convection outside tubes.

**Heat transfer to fluids with phase change**

Heat transfer from condensing vapors, heat transfer to boiling liquids.

**Unit- IV:**

**Heat exchange equipment**

General design of heat exchange equipment, heat exchangers, condensers, boilers and calendrias, extended surface equipment, heat transfer in agitated vessels, scraped surface heat exchangers, heat transfer in packed beds, heat exchanger effectiveness (NTU method)

**Evaporators**

Evaporators, performance of tubular evaporators, capacity and economy, multiple effect evaporators, vapor recompression.

**Unit- V:**

**Radiation**

Introduction, properties and definitions, black body radiation, real surfaces and the gray body, absorption of radiation by opaque solids, radiation between surfaces, radiation shielding, radiation to semitransparent materials, combined heat transfer by conduction, convection and radiation.

**COURSE OUTCOMES:**

1. Student able to understand the basic concepts and laws of the three modes of heat transfer

2. Student can able to Determine heat transfer coefficients for forced and natural convection & concept of fouling

3. Student will analyze the heat transfer processes involved in boiling and condensation

4. Student can perform basic calculations of common heat exchangers and evaporators

5 Student will analyze the heat radiation in detail

**TEXT BOOKS:**

1. Unit Operations of Chemical Engineering, 6th ed., W.L. McCabe, J.C. Smith and P. Harriot, McGraw-Hill, New York, 2001

**REFERENCES:**

1. Heat transfer, 4th edition, J. P. Holman , McGraw-hill, New York,1976.
2. Heat transfer: Principles and Applications. B.K. Dutta, PHI Learning, India, 2004
3. Process Heat Transfer, D.Q. Kern, Tata McGraw-Hill, New Delhi, 1997

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**II B.Tech. – II Sem**

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## PROBABILITY & STATISTICS
## (Common to CSE, IT and CHEM)

**Prerequisites:** Mathematics – I and II

**Course Objectives:**

1. Understand Chance causes and random variable that describes randomness or an uncertainty in certain realistic situation. It can be of either discrete or continuous type.
2. In the discrete case, study of the binomial and the Poisson random variables and the Normal random variable for the continuous case predominantly describe important probability distributions. Important statistical properties for these random variables provide very good insight and are essential for industrial applications.
3. To perform polynomial Curve Fitting , General Curve fitting and Interpolation , various types of Skewness and kurtosis , Correlations .
4. The types of sampling, Sampling distribution of means ,Sampling distribution of variance, Estimations of statistical parameters, Testing of hypothesis of few unknown statistical parameters.
5. Understanding the Experiments.

**UNIT-I:** Introduction to Probability, Addition theorem, Multiplication theorem (Two events only), Baye's theorem.
Random variables, Discrete and continuous random variable, Definitions of Probability Distribution function, Probability mass function, Probability density function and properties. Definitions of Mathematical expectation, Variance of discrete and continuous random variable. Bivariate distributions and their properties, marginal and conditional distribution

**UNIT-II:**
Discrete Distributions: Bernoulli, Binomial, Poisson distributions (definition and problems) their mean, variance and moment generating function.
Continuous Distribution: Normal, exponential distributions (definition and problems) related properties.

**UNIT-III:**
Measures of Central tendency: Moments, Skewness and Kurtosis.
Curve fitting by the method of least squares- fitting of straight lines, second degree parabolas and more general curves.
Correlation and regression – Rank correlation

**UNIT-IV:**

Estimation: Concept of Point estimation and its properties (definition only), Concept of interval estimation with examples.

Test of Hypothesis: Null & Alternative Hypothesis, Critical region, Type I and Type II errors, level of significance, one tail, two-tail tests.

Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means

**UNIT-V:**

Small Sample tests: t-Test for single mean, difference of means, paired t-test, F-test.
Chi-square test for goodness of fit and independence of attributes.
ANOVA: Introduction, ANOVA for one way classification only.

**Course Outcomes:**

1. Identify distribution in certain realistic situation. It is mainly useful for circuit as well as non-circuit branches of engineering. Also able to differentiate among many random variables involved in the probability models. It is quite useful for all branches of engineering.

2. Calculate mean and proportions (small and large sample) and to make important decisions from few samples which are taken out of unmanageably huge populations. It is mainly useful for non-circuit branches of engineering.
3. To interpolate using curve fitting and identify the Correlation between variables.
4. To estimate an unknown population parameter.
5. Design their experiment with the basic norms and test their design efficiency. It is useful to all the branches of engineering.

**Text Books:**

1. Probability and Statistics for Engineers and Scientists by Sheldon M. Ross, Academic Press.
2. Probability and Statistics for Engineers by Richard A Johnson, Pearson Education.

**References:**

1. Introduction to Probability by Charles M Grinstead, J Laurie Snell, American Mathematical Society.
2. Miller and John E. Freund, Probability & Statistics for Engineers, Prentice Hall of India.
3. Montgomery: Design and Analysis of Experiments, Wiley

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| II B.Tech. – II Sem | L | T/P/D | C |
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## CHEMICAL ENGINEERING THERMODYNAMICS-II

**PREREQUISITE:** Chemical Engineering Thermodynamics-1, Mathematics

**COURSE OBJECTIVES:**

1. Calculate the heat effects of Industrial Reactions.
2. Familiarity with basic concepts in solution thermodynamics.
3. Solve problems involving Vapor Liquid Equilibrium.
4. Explain the underlying principles of phase equilibrium in two-component and multi-component systems
5. Determine equilibrium compositions for chemical reactions.

**Unit -I:**

**Heat effects**: Sensible heat effects; Latent heats of pure substances; Standard heat of reaction; Standard heat of formation; Standard heat of combustion; temperature dependence of heat of reaction; heat effects of industrial reactions.

**Unit-II:**

**Solution thermodynamics: Theory:** Fundamental property relation; chemical potential as a criterion for phase equilibrium; partial properties; ideal gas mixture model; fugacity and fugacity coefficient for pure species; Fugacity and fugacity coefficient for species in solutions; generalized correlations for Fugacity coefficient; the ideal solution model; excess properties.

**Solution thermodynamics: applications:** the liquid phase properties from VLE data; models for the excess Gibbs energy; property changes of mixing; heat effects of mixing processes.

**Unit -III:**

**VLE at low to moderate pressures:** The nature of equilibrium; the phase rule - Duhem's theorem; VLE: Qualitative behaviour; Simple models for vapour liquid equilibrium; Vapor liquid equilibrium by Modified Raoult's law; VLE from K-Value Correlations.

The gamma /Phi formulation of VLE; Dew point and bubble point calculations; flash calculations; solute (1)/sol vent (2) systems.

**Unit –IV:**

**Thermodynamic properties and VLE from equations of state:** VLE from cubic equations of state.

**Topics in phase Equilibria:** Equilibrium and stability; liquid-liquid equilibrium (LLE); vapor- liquid–liquid equilibrium (VLLE); solid-liquid equilibrium (SLE); solid vapor equilibrium (SVE); equilibrium absorption of gases on solids.

**Unit –V:**

**Chemical reaction equilibria:** The reaction coordinate; application of equilibrium criteria to chemical reactions; the standard Gibb's energy change and the equilibrium constant; effect of temperature on equilibrium constant; relation of equilibrium constants to composition; equilibrium conversion for single reactions; Phase rule and Duhem's theorem for reacting systems, Multireaction equilibria.

**Introduction to molecular thermodynamics:** Molecular theory of fluids; Internal energy of ideal gases: Microscopic view.

**COURSE OUTCOMES:**

**Students will be able to:**

1. Analyze the heat effects involved in Industrial Chemical Processes.
2. Determine the thermodynamic properties of mixtures of gases, liquids and solids.
3. Calculate vapor-liquid equilibrium (VLE) composition for ideal and non-ideal systems
4. Determine the equilibrium states of a wide range of systems, ranging from mixtures of gases, liquids, and solids that can each include multiple components.
5. Solve problems dealing with multi-phase chemical systems and reactive systems.

**TEXT BOOKS:**

1. Smith , J.M., Van Ness, H.C. and Abbott.M.M., " Introduction to Chemical Engineering Thermodynamics ", 7th ed, Mc Graw Hill, 2005.

**REFERENCES:**

1.S.Sandler, "Chemical, Biochemical and Engineering Thermodynamics", 4th Ed, Wiley, India.

2. Kyle, B.G., "Chemical and Process Thermodynamics 3rd edn. ", Pearson, Prentice Hall of India Pvt.Ltd., 1999.

3. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press Pvt Ltd, 2004.

4. K.V. Narayanan, "A Text Book Chemical Engineering Thermodynamics", PHI Learning Pvt Ltd., New Delhi, 2001.

5. Hougen O.A, Watson. K. M and Ragatz R.A., "Chemical Process Principles (part II)", 2nd Ed, CBS Publishers, 2004.

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## MATERIAL SCIENCE AND ENGINEERING

**PREREQUISITE:** First year physics, Chemistry & Mathematics

**Course Objectives:**
The objective of the course is to give the students

1. An introduction on how to apply advanced sciences to various material systems
2. Understanding and Categorization of different principles related to materials and systems relevant to Chemical Engineering in particular.
3. The importance of phase diagrams for studying properties of materials
4. How to relate the underlying molecular structure of the materials to their physical and chemical properties, and their processing and performance characteristics.
5. To identify problems related to materials

**UNIT-1**
Introduction to materials, bonding between atoms: metallic bonding, ionic bonding, covalent bonding, Van der Waals bond, thermal coefficient expansion, elastic modulus, Role of materials selection in design, structure-property relationships Miller indices of directions and planes, packing of atoms inside solids, close-packed structures, structure of ceramics, ionic solids, glass and polymers, density of various materials.

**UNIT-II- CRYSTAL IMPERFECTIONS**
Imperfections in solids: vacancies, equilibrium concentration of vacancies, interstitial and substitutional impurities in solids, dislocations, types and characteristics of dislocations, interfacial defects, stacking faults.
Structure of materials and Strength of Materials: Yield strength, tensile strength and ductility of materials: stress strain behavior of metals, ceramics and polymers, creep behavior and fatigue

**UNIT-III**
Basic thermodynamic functions; phase diagrams and phase transformation: Primary and binary systems-general types with examples; tie line& lever rules, non-equilibrium cooling. Phase transformations in Fe-$Fe_3C$ steels, Time-Temperature-Transformation (TTT) curves for eutectoid steels and plain carbon steels; effect of alloying elements on properties of steels; types of steels, phase diagrams of Pb-Sn, Cu-Ni systems.

**UNIT-IV**
Semi-crystalline materials: Classification, structure and configuration of ceramics, polymers, copolymers, liquid crystals and amphiphiles
Non-crystalline/amorphous materials: Silicates, glass transition temperature, viscoelasticity

Polymer composites (FRP) Fiber reinforced composite, Polymer Nano-composite materials: Nano-composites, role of reinforcement-matrix interface strength on composite behavior. Material related to catalyst such as zeolites, silica etc. and other selected materials

**UNIT-V**

Corrosion, Degradation and Recycling

Introduction to experimental techniques: XRD, etc. for material characterization highlighting links between molecular structure and macroscopic properties (3 contact hrs.), Tensile test, GPC, Microscopy, SEM.

**Course outcomes: Students will able to**

1. Analyze & apply advanced science and engineering principles to materials systems.
2. Categorize the scientific and engineering principles underlying the major elements of the field related to materials & systems appropriate to the field.
3. Analyze and apply concepts of Phase diagrams for studying properties of materials
4. Able to apply and study the microstructure, properties, processing and performance of materials
5. Able to formulate plans to solve problems related to materials.

**Text Books:**

1. V. Raghavan Materials Science and Engineering: A First Course, 5th Edition Prentice Hall India, 2004.
2. William D. Callister, David G. Rethwisch Materials Science and Engineering: An Introduction, Wiley Publisher.

**REFERENCES:**

1. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
2. S. Upadhyaya & A. Upadhyaya, Material Science and Engineering, Anshan Publications, 2007.
3. B. S. Mitchell an Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

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**II B.Tech. – II Sem**

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## CHEMICAL TECHNOLOGY

**PREREQUISITES:** Chemistry, Mechanical unit operations

**COURSE OBJECTIVES:** By studying this subject students will learn about

1. Inorganic Industries
2. Fertilizer industries
3. Organic Chemical Industries
4. Petrochemicals
5. Polymer Industries

**UNIT- I**

**Inorganic Industries**

Chlor-Alkali Industry-Manufacture of Soda ash, caustic soda and chlorine, Sulfur and sulfuric acid, Cement-Portland cement and Special cement.

**Unit – II**

**Fertilizer industries**

Nitrogen Industries: manufacturing and uses: Ammonia, Urea and Nitric acid.

Phosphorous Industries: manufacturing and uses of Phosphoric acid and Calcium Phosphate

Potash industries: Production of NPK fertilizers, potassium sulphate, potassium chloride

**Unit – III**

**Organic Chemical Industries**

Oils: Definition, constitution, extraction of vegetable oils, refining and hydrogenation of oils.

Soaps and Detergent, Carbohydrate- Sugar and Starch: Manufacture of cane sugar

Pulp and Paper Industry: Methods of pulping production of sulphates and sulphite pulp. Recovery of chemicals from black liquor

**Unit – IV**

**Petrochemicals:** Manufacture and uses of Formaldehyde, Acrylonitrile, Vinyl Acetate, ethanolamines and Aromatics

**Unit – V:**

**Polymer Industries :** Introduction, Fibre-manufacturing of Nylon66, Plastic-manufacturing of Polyethylene, Polycondensation-production of Phenol formaldehyde, Elastomer-manufacturing of Rubber and Cellulosic – Rayon.

**COURSE OUTCOMES**:

Upon the successful completion of the course, the student will be able to:

1. Understand inorganic and organic chemical technologies.

2. Understand the synthesis methods of nitrogen industries

3. Understand engineering problems in chemical processes.

4. Analyze different methods and processes used in cement manufacture

5. Understand the manufacturing processes of various petrochemicals

**TEXT BOOKS:**

1. Shreve's Chemical Process Industries edited by Austin, McGraw-Hill.5th ed.1985.
2. Dryden's Outlines of Chemical Technology, edited by M.Gopal Rao and M.Sittig, 2nd ed. 1973.

**REFERENCES:**

1. Industrial Chemistry by B.K.Sharma
2. Hand book of industrial chemistry Vol 1&II K.H.Davis & F.S. Berner, edited by S.C. Bhatia, CBS publishers

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| II B.Tech. – II Sem | L | T/P/D | C |
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## ENVIRONMENTAL BIOTECHNOLOGY

**PREREQUISITE:** Environmental Science, Engineering Chemistry

**COURSE OBJECTIVES: Students will able to**

1. To understand the role of various environmental pollutants, bio-oxidation, Biosorption.
2. To learn the importance of biological waste treatment.
3. To understand the biodegradation of xenobiotic compounds.
4. To learn about biotransformations, bioremediation and biorestoration.
5. To understand biooxidation, microbial leaching and biotechnology in protection of environment.

**UNIT-I**

**Introduction to environmental pollutants:** Water, Soil and Air: their sources and effects. Removal of Specific Pollutants: Sources of Heavy Metal Pollution, Microbial Systems for Heavy Metal Accumulation, Biosorption & detoxification mechanisms.

**Eco-friendly bio-products from renewable sources:** Fundamentals of composting process: composting technologies, composting systems and compost quality,

**UNIT-II**

**Biological waste treatment:** Biological waste water treatment: Principles and design aspects of various waste treatment methods with advanced bioreactor configuration: activated sludge process, trickling filter, fluidized expanded bed reactor, up flow anaerobic sludge blanket reactor, contact process, fixed/packed bed reactor, hybrid reactor, sequential batch reactor. Solid waste management: landfills, recycling and processing of organic residues, minimal national standards for waste disposal

**UNIT-III**

**Biodegradation of xenobiotic compounds:** Xenobiotic compounds: Aliphatic, Aromatics, Poly aromatic Hydrocarbons, Polycyclic aromatic compounds, Pesticides, Surfactants and microbial treatment of oil pollution.

**UNIT-IV**

**Biotransformations and biocatalysts:** Basic organic reaction mechanism - Common prejudices against Enzymes.- Advantages & Disadvantages of Biocatalysts - Isolated Enzymes versus whole cell systems.- Mechanistic Aspects and Enzyme Sources.-Bio-catalytic Application - Catalytic Antibodies; Stoichiometry, kinetics, and thermodynamics of microbial processes for the transformation of environmental contaminants.

**Bioremediation and bio-restoration**: Introduction and types of bioremediation, bioremediation of surface soil and sludge, bioremediation of subsurface material, in-situ and Ex-situ technologies, and phytoremediation- restoration of coal mines a case study. Bio restoration.

**UNIT-V**

**Biooxidation & microbial leaching:** Bio-oxidation – Direct and Indirect Mechanisms – Bio-oxidation Kinetics; Bacterial oxidation of Sphalerite, Chalcopyrite and Pyrite.; Extraction of metals from ores; Recovery of metals from solutions; Microbes in petroleum extraction; Microbial desulfurization of coal.

**Biotechnology in environment protection**: Current status of biotechnology in environment protection and its future, plasmid borne metabolic activities, bio augmentation.

**COURSE OUTCOMES: Students will able to**

1. Understand the role of environmental biotechnology in order to make environment in sustainable manner.
2. Apply different methods of biological treatment of wastewater.
3. Analyze the biodegradation of aliphatic and aromatic compounds.
4. Explain the importance of bioremediation and bio-restoration.
5. Understand the importance of biotechnology in environment protection.

**TEXTBOOKS:**

1.Environmental Processes I-III, J. Winter, 2nd ed., Wiley Publications

2 Introduction to Waste Water Treatment- R. S. Ramalho, Academic Press.

3.Bharucha Erach, the Biodiversity of India, Mapin Publishing Pvt. Ltd.

4.Environmental Biotechnology, B.C. Bhattacharya & Ritu Banerjee, Oxford Press, 2007.

**REFERENCES:**

1. Environmental Biotech, Pradipta Krimar, I.K. International Pvt. Ltd., 2006.

2. Environmental Microbiology & Biotechnology, D.P. Singh, S.K. Dwivedi, New Age International Publishers, 2004.
3. Biodegradation and Bioremediation 1999 (2nd editon). Martin Alexander, Elsevier Science & Technology.
4. Environmental Biotechnology by Bruce Rittmann and Perry McCarty Subas, V. Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.

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**II B.Tech. – II Sem**

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## TECHNOLOGY OF PHARMACEUTICALS AND FINE CHEMICALS

**PREREQUISITE:** First year Chemistry

**COURSE OBJECTIVES**

Students will learn about

1. Grading of chemicals which play a very important role in understanding the standards and impurities present in different chemicals by limit test
2. Process manufacturing of few pharmaceutical drugs and fine chemicals,
3. Formulations of different pharmaceutical dosage forms like tablets and capsules.
4. Different methodologies in extraction and sterilization.
5. Importance of pharma packaging.

**Unit I:**
A brief outline of grades of chemicals, sources of impurities in chemicals.
Limit test, principles of limit test for arsenic, lead, iron, chloride and sulfate in Pharmaceuticals.

**Unit II:**
Outlines of Preparation, properties, uses and testing of the following Pharmaceuticals - sulfacetamide, paracetamol, riboflavin, nicotinamide, Penicillin, Chloramphenicol. Outlines of Preparation, properties, uses and testing of the following fine chemicals - Methyl orange, fluorescence, procaine hydrochloride, paramino salicylic acid, isonicatinic acid hydrazide, Pthallic Anhydride.

**Unit III:**
Brief on different drug delivery systems (tablets, capsules, injections, topical applications etc). Tablet making and coating, granulation equipment, packaging and preparation of capsules, extraction of crude drugs.

**Unit IV:**
Sterilization: Introduction, methods of sterilization, heat (dry and moist), heating with bactericide, filtration, gaseous sterilization and radiation sterilization, suitable examples to be discussed.

**Unit V:**
Introduction to Packaging, Classification of Packaging, Essential Requirements, Functions of Packaging, Importance / significance of Pharma Packaging, Properties of Ideal Package, Packaging formats in Pharma Industry, Packaging recycling symbols, FDA Definitions, Introduction to Packaging materials, Classification, Approach to package design, New Trends in the pharmaceutical packaging, Various materials and pharma Packaging,

**COURSE OUTCOMES: Students will able to**

1. Able to identify impurities in different chemicals and set them according to standards.
2. Able to transforming raw materials into useful pharmaceutical and fine chemical products with commercial interest through systematic use of engineering concepts and methods.
3. Able to formulate and develop, use of excipients in tablets, capsules and coating techniques.
4. Get exposed to extraction and sterilization techniques in pharmaceuticals.
5. Able to classify various materials used in Pharma packaging industry.

**TEXT BOOKS:**

1. Bently's TEXT BOOK of Pharmaceutics by H A Rawlins, B Tindell and Box, 8th ed. OU Press, London, 1977.
2. Remington's Pharmaceutical Science, Mac publishing company, 13th ed. 1965.

**REFERENCES:**

1. Text Book of Pharmaceutical Chemistry by Bently and driver. Oxford University press, London, 8th ed. 1960.

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| II B.Tech. – II Sem | L | T/P/D | C |
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## WATER CONSERVATION AND MANAGEMENT

**Prerequisite**: Environmental studies.

**COURSE OBJECTIVES:**

1. To enable the students to understand various types of water conservation methods.
2. To discuss the concept of water audits.
3. To study the various methods for water quality control.
4. To illustrate the methods of water conservation in process industry.
5. To understand the various water management systems.

**UNIT I:**

Introduction: water cycle, water storage, water quality; water conservation in homes; water conservation in the work place, water resources and irrigation development in India.

**UNIT II:**

Water management- water quality, controlling use and quality of water, water flow measurement, water sources and challenges, water convergence and control.

**UNIT III:**

Water quality control, testing water salinity, preserving water quality, minimizing evaporation, Watershed restoration and conservation through reforestation.

**UNIT IV:**

Water sanitation, Introduction and need of water auditing; data requirement, water conservation in agriculture, water harvesting, subsurface dams, water purification systems.

**UNIT V:**

Water conservation in process industry; water conservation in construction industry; Conservation drainage - Necessity, methods and design of surface and substance drainage, drainages of irrigated lands, interceptor relief drains and tile drains and their design, drainage requirements of crops, drainage in relation salinity control.

**COURSE OUTCOMES:**

1. Ability to understand the water conservation methods available in India.
2. Know importance of water management and water flow measurement along with its controlling use.
3. Gain the knowledge of various types of water quality control strategies.
4. Understand about water sanitation and water audits.
5. Develop awareness of water conservation in process industry.

**TEXT BOOKS:**

1. Water resources systems planning and Management, Jain and Singh, Elsevier Publishers, 1st Edition.

2. Water conservation and management, Judith Rosales, Arcler Education Inc.

**REFERENCES:**

1. Water resources conservation and management, S.N. Chatterjee, Atlantic edition.

2. Water conservation, management and analysis, Madireddy V. Subba Rao, Readworthy.

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## PROCESS HEAT TRANSFER LAB

**COURSE OBJECTIVES:** Students will learn about

1.To Calculate of the thermal conductivity.

2.To Calculate of heat transfer coefficient for natural convection.& Forced Convection

3.To Determine of emissivity of a test plate.

4. To Determine Stefen Boltzmann constant

5. To Determine overall heat transfer coefficient in heat exchanger

(At least **Ten** experiments should be performed)

1. Determination of total thermal resistance and thermal conductivity of composite wall
   Major equipment-Composite wall Assembly
2. Determination of thermal conductivity of metal rod.
   Major equipment-Thermal conductivity apparatus
3. Determination of natural convection heat transfer coefficient for a vertical tube.
   Major equipment-Natural convection heat transfer apparatus.
4. Determination of critical heat flux point for pool boiling of water.
   Major equipment-Pool boiling apparatus
5. Determination of forced convective heat transfer coefficient for air flowing through a pipe.
   Major equipment-Forced convection heat transfer apparatus
6. Determination of overall heat transfer coefficient in double pipe heat exchanger.
   Major equipment-Double pipe heat exchanger apparatus
7. Study of the temperature distribution along the length of a pin-fin under natural and forced convections.
   Major equipment-Pin-fin apparatus
8. Determination the heat transfer through concentric spheres.
   Major equipment: concentric sphere Apparatus.
9. Determination of Stefan-Boltzmann constant.
   Major equipment-Stefan-Boltzmann apparatus
10. Determination of emissivity of a given plate at various temperatures.
    Major equipment-Emissivity determination apparatus.
11. Determination of Capacity and Economy by Single Effect Evaporator
    Major Equipment- Evaporator.

**COURSE OUTCOMES:**

Upon the successful completion of the course, the student will be able to:

1.Calculate of the thermal conductivity.

2.Calculate of heat transfer coefficient for natural convection.& Forced convection

3.Determine of emissivity of a test plate.

4. Determine Stefen Boltzmann constant

5.Determine overall heat transfer coefficient in heat exchanger.

**TEXT BOOKS:**

1. Unit Operations of Chemical Engineering, 6th ed., W.L. McCabe, J.C. Smith and P. Harriot, McGraw-Hill, New York, 2001

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## CHEMICAL TECHNOLOGY LAB

**PREREQUISITE:** First- & Second-year Chemistry,

**COURSE OBJECTIVE**

1. To learn analytical experimental methods
2. To understand principles and concepts
3. To plan experiments and operate sophisticated instruments
4. To analyze and interpret experimental data
5. To handle experiment with all safety measures needed

List of Experiments

(Minimum of **TEN** in the list is to be performed out of **TWELVE**)

1. Analysis of Iron ore
2. Analysis of copper ore
3. Estimation of Borax
4. Estimation of dissolved oxygen in Water
5. Estimation of Calcium Ions in Water
6. Solubility tests in vegetable oils
7. Estimation of Formaldehyde in formalin solution
8. Estimation of Glucose
9. Preparation of Nitro-benzene
10. Preparation of Meta dinitro benzene
11. Preparation of Acetanilide
12. Determination of $\lambda_{max}$ of solution & verify Beer's law by finding out the concentration of unknown solution.
13. Estimation of acetyl salicylic acid present in aspirin tablets

**COURSE OUTCOMES**

- Ability to explain and select instrumental techniques for analysis
- Ability to plan experiments and operate several specific instruments
- Ability to analyse and interpret the experimental data
- Ability to develop and apply preparation methodologies for various
- Ability to complete experiments safely

**TEXT BOOKS:**

1. Harris C. H., "Quantitative chemical analysis", 7th Ed., W. H. Freeman, New York, 2006.
2. Willard H. H., and Meritt, L. L., "Instrumental methods of Analysis", 7th Ed., ACS Publications, 1989.

**REFERENCES:**

2. Skoog A. D., Holler, F. J., Stanley, R. C., "Principles of Instrumental Analysis", 7th Ed., Brookes Cole, 1997.
3. S. K. Bhasin and Sudha Rani, "Laboratory manual in engineering chemistry", Dhanpathrai Pub. Company, 2009.

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## ENVIRONMENTAL STUDIES

**PREREQUISITES: Engineering Chemistry**

**COURSE OBJECTIVES:**

1. To introduce the knowledge about Environment.
2. To introduce students to the concepts of pollution, Biodiversity
3. To develop an awareness about global Environmental problems.
4. To learn to protect environment and awareness on legal issues
5. To learn about importance of sustainable development and role of IT in environment.

**UNIT – I**

**Multidisciplinary nature of Environmental Studies**: Definition, Scope and Importance – Need for Public Awareness.

**Ecosystems**: Concept of an ecosystem – Classification, structure and function of different ecosystems - Producers, consumers and decomposers. - Energy flow in the ecosystem - Ecological succession - Food chains, food webs and ecological pyramids.

**Biodiversity and its conservation**: Introduction - Definition: genetic, species and ecosystem diversity. - Bio-geographical classification of India - Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values. India as a mega-diversity nation - Hot-spots of biodiversity - Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. ICUN categories of biodiversity and RED DATA book - Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

**UNIT – II**

**Natural Resources**: Renewable and non-renewable – Natural resources and associated problems: Forest resources – Use and over – exploitation, deforestation,– Timber extraction, mining, dams and other effects on forest and tribal people: Water resources – Use and over utilization of surface and ground water – Floods, drought, conflicts over water, dams – benefits and problems – Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources. - Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity. - Energy resources: Growing energy needs, renewable and non-renewable energy sources use of alternate energy sources. Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification. Role of an individual in conservation of natural resources: Equitable use of resources for sustainable lifestyles.

**UNIT – III**

**Environmental Pollution**: Definition, Cause, effects and control measures of different kinds of pollution (Air, Water, Soil, Marine, Noise, Thermal, Nuclear, e –Waste)
**Carbon Capture & Sequestration – d**ifferent storage sources, major disadvantages, environmental effect**s**
**Social Issues and the Environment**: From Unsustainable to Sustainable development -Urban problems related to energy -Water conservation, rain water harvesting, and watershed management. -Climate change, global warming, ozone layer depletion, nuclear accidents and holocaust.

**UNIT – VI**

**Waste management technology:** Solid waste Management: Causes, effects and control measures of urban and industrial wastes. - Role of an individual in prevention of pollution, Disaster management: floods, earthquake, cyclone and landslides.

Waste water and sewage treatment technology: primary, secondary and tertiary treatments. Bioremediation, Phyto-remediation, ZLD (zero liquid discharge), membrane technology. Application of GIS and GPS system in environmental science.

**Environmental policy, Rules and regulations.** EIA (Environmental Impact Assessment) & EMP (ENVIRONMENTAL Management Plan) – Environment Protection Act. - Air (Prevention and Control of Pollution) Act. -Water (Prevention and control of Pollution) Act -Wildlife Protection Act –Forest Conservation Act.-Public awareness. Global environmental problems and global efforts.

**UNIT – V**

**Towards sustainable future**: concept of sustainable development, threats of sustainability, population and its explosion, over exploitation of resources, strategies for achieving sustainable development. Environmental education, Conservation of resources. Urban sprawl, sustainable cities and sustainable communities, human health. Role of IT in environment, environmental ethics, concept of green building, Basic principles of Green engineering, clean development mechanism (CDM), Low carbon life cycle, Polluters-pay principle.

**COURSE OUTCOMES:**

1. Understand fundamental physical and biological principles that govern natural processes.
2. Understand fundamental concepts from the social sciences and humanities underlying environmental thought and governance
3. Integrate and apply perspectives from across the natural sciences, social sciences, and the humanities in the context of complex environmental problems.

4. Communicate integrated perspectives on complex environmental problems in the form of written and oral argument to both professional and lay audiences.

5. Design and conduct independent research that contributes to environmental thought and/or problem solving.

**TEXT BOOKS:**

1. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha, University Press Private Limited, Reprinted in 2005.

2. Environmental Studies: From Crisis to Cure by R.Rajagopalan, Oxford University Press, 2nd Edition, 2005

**REFERENCES:**

1. Environmental Science: Towards a Sustainable Future by Richard T.Wright. PHL Learning Private Ltd .New Delhi, 2008

2. Environmental Engineering and science by Gilbert M.Masters and Wendell P.Ela. PHI Learning Pvt. Ltd. 4th edition, 2008

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**III B.Tech. – I Sem**

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## CHEMICAL REACTION ENGINEERING-I

**PREREQUISITE:** Chemical Process Calculations, Chemistry, Mathematics-I, II, III

**COURSE OBJECTIVES: Students will able to**

1. To understand design of Reactor.
2. To Identity type of reactor by using chemical kinetics and using Information from Thermodynamics
3. Heat transfer and Mass Transfer.
4. To study and Identify type of reaction.
5. To Study and understand effect of Temperature and pressure reaction.

**UNIT-I**

Overview of chemical reaction engineering - classification of reactions, variables affecting the rate of reaction, definition of reaction rate, kinetics of homogeneous reactions-concentration dependent term of rate equation, temperature dependent term of rate equation, searching for mechanism, predictability of reaction rate from theory.

**UNIT-II**

Interpretation of batch reactor data-constant volume batch reactor-Analysis of total pressure data obtained in a constant-volume system, the conversion, Integral method of analysis of data-general procedure, irreversible uni-molecular type first order reaction, irreversible bimolecular type second order reaction, irreversible tri molecular type third order reactions, empirical reactions of nth order, zero order reaction, overall order of irreversible reaction from half-life, fractional life method, irreversible reaction in parallel, homogeneous catalyzed reaction, autocatalytic reactions, irreversible reaction in series.

**UNIT-III**

Constant volume batch reactor-first order reversible reaction, second order reversible reactions, reversible reaction in general, reactions of shifting order, Differential method of analysis of data, Varying volume batch reactor-differential method of analysis ,integral method of analysis, zero order first order, second order, nth order reactions, temperature and reaction rate, the search for a rate equation. Introduction to reactor design - general discussion. Symbols and relationship between $C_A$ and $X_A$, Ideal reactors for a single reaction-ideal batch reactor, Steady-state mixed flow reactor, Steady-state plug flow reactor.

**UNIT-IV**

Design for single reactions-Size comparison of single reactors, multiple reactor systems, recycle reactor, Autocatalytic reactions. Design for parallel reactions-Introduction to multiple reactions, qualitative discussion about product distribution, quantitative discussion about product distribution and of reactor size.

**UNIT-V**

**Series Reactions** - Irreversible first order reactions in series, quantitative discussion about product distribution, quantitative treatment, plug flow or batch reactor, quantitative treatment, mixed flow reactor, first order followed by zero-order reaction, zero order followed by first order reaction.

**Temperature and pressure effects**-single reactions-heats of reaction from thermodynamics, heats of reaction and temperature, equilibrium constant from thermodynamics, equilibrium conversion, general graphical design procedure, optimum temperature progression, heat effects, endothermic reaction in mixed flow reactors-A special problem, multiple reactions, adiabatic operation, non-adiabatic operation comment and extension.

**COURSE OUTCOMES: Students will able to**

1. Describe the algorithm that allows the student to solve chemical reaction engineering problems through logic rather than memorization.
2. Determine the reaction order and specific reaction rate from experimental data and describe the steps in a catalytic mechanism and how one goes about deriving a rate law, mechanism, and rate-limiting step that are Consistent with experimental data.
3. Work together to solve both open-ended and closed-ended reaction engineering problems.
4. Use relevant theory to describe the molecular basis for elementary chemical reaction rates.
5. Understand the temperature and pressure effects on chemical reactions

**TEXT BOOKS**:

1. Chemical reaction engineering by Octave Levenspiel, 3rd ed. John Wiley and Sons, 1990.

**REFERENCES:**

1. Elements of Chemical reaction engineering by H.S. Fogler, 2nd ed.PHI,1992.
2. Chemical engineering Kinetics by J.M. Smith, 3rd ed. Mc Graw Hill, 1981.

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**III B.Tech. – I Sem**

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## MASS TRANSFER OPERATIONS-I

**PREREQUISITE:** Fluid Mechanics, Chemical Process Calculations

**COURSE OBJECTIVES:**
The objective of this course is

1. To discuss the fundamental concepts of mass transfer principles and to apply those concepts to real engineering problems.
2. To impart the basic concepts of molecular diffusion, mass transfer coefficients and analysis of different mass transfer processes
3. Applies the concepts of diffusion mass transfer, mass transfer coefficients, convective mass transfer, inter-phase mass transfer, equipment for gas-liquid operations.
4. To provide theoretical/analytical back ground to understand mass transfer operations like to tackle the complex problems
5. Design aspects of the equipments utilized for absorption, humidification and drying operations.

**UNIT- I**
**The Mass Transfer Operations:** Classification of the Mass-Transfer Operations, Choice of Separation Method, Methods of Conducting the Mass-Transfer Operations, Design Principles, Molecular Diffusion In Fluids: Molecular Diffusion, Equation of Continuity, binary solutions, Steady State Molecular Diffusion in Fluids at Rest and in Laminar Flow, estimation of diffusivity of gases and liquids, Momentum and Heat Transfer in Laminar flow Diffusion: Diffusion in Solids, Fick's law Diffusion, Types of Solid Diffusion.

**UNIT- II**
**Mass Transfer Coefficients:** Mass Transfer Coefficients, Mass Transfer Coefficients in Laminar Flow (Explanation of equations only and no derivation), Mass Transfer Coefficients in Turbulent Flow, eddy diffusion, theories of mass transfer and their applications , Mass, Heat and Momentum Transfer Analogies, Inter phase Mass Transfer: Concept of Equilibrium, Diffusion between Phases, Material Balances in steady co-current and counter current stage processes, Stages, Cascades

**UNIT-III**
**Equipment For Gas-Liquid Operations:** Gas Dispersed, Sparged vessels (Bubble Columns), Mechanical agitated equipments(Brief description),Tray towers, General characteristics, Different types of Tray Efficiencies, Liquid Dispersed venturi Scrubbers, Wetted-Wall Towers, Packed Towers, Mass transfer for packed towers, End effects and Axial Mixing, Tray tower vs Packed towers.
**Absorption and Stripping:** Absorption equilibrium, ideal and non ideal solutions selection of a solvent for absorption, one component transferred: material balances. Determination of number of Plates (Graphical),Absorption Factors, estimation of number of plates by Kremser

Brown equation, Continuous contact equipment; HETP, Absorption of one component, Determination of number of Transfer Units and Height of the Continuous Absorber, overall coefficients and transfer units, dilute solutions, overall height of transfer units

**UNIT-IV**

**Humidification Operations**: Vapor-Pressure Curve, Definitions, Psychometric Charts, Enthalpy of gas-vapor Mixtures, Humidification and Dehumidification, Operating lines and Design of Packed Humidifiers, Dehumidifiers and Cooling towers, Spray Chambers

**UNIT-V**

**Drying:** Equilibrium, Definitions, Drying Conditions- Rate of Batch Drying under constant drying conditions, Mechanisms of batch drying, Drying time Through Circulation Drying, Classification of Drying Operations: Batch and Continuous Drying Equipment, Material and Energy Balances of Continuous Driers.

**COURSE OUTCOMES:**

Students will be

1. Estimate diffusion coefficients, Solve unsteady state diffusion problems.
2. Determine convective mass transfer rates & mass transfer coefficients and related mass transfer theories.
3. Perform material and energy balance calculations in mass transfer operations humidification, drying, and absorption operations.
4. Able to select and design the equipments for humidification, drying and absorption operations.
5. Determine the number of transfer units and height requirements for a packed column

**TEXT BOOKS:**

1. Mass transfer operations by R.E. Treybal, 3rd ed. Mc Graw Hill, 1980.
2. McCabe, W.L., Smith, J.C., and Harriot, P., "Unit Operations in Chemical Engineering", McGraw-Hill VII Edn., 2004.

**REFERENCES:**

1. Diffusion: mass transfer in fluid system by E. L. Cussler, 2nd Ed, 1997.
2. Transport processes and Separation Process Principles 4th Ed., by Christie J. Geankoplis, PHI Learning Pvt. Ltd., New Delhi, 2009
3. Principles of mass transfer and separation processes, Binay .K. Dutta, PHI Learning Pvt Ltd, India, 2007
4. S. Foust, Principles of Unit Operations, 2nd Edition, Wiley, New York, 1980.

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## POLYMER SCIENCE AND ENGINEERING

**Prerequisite:** Engineering Chemistry, Chemical Technology

**COURSE OBJECTIVES: Students will able**

1. To enable the students to compute molecular weight averages from the molecular weight distribution.
2. To enable the students to understand the importance of natural polymers.
3. To learn the mechanisms and kinetics involved in polymerization.
4. To enable the students to understand the methods and properties of polymerization.
5. To learn the manufacturing of different types of polymers.

**UNIT-I**

**Introduction:** definitions: Polymer& macro molecule, monomer, functionally, average functionally, co-polymer, polymer blend, plastic and resin's classification of polymers: based on resource, structure, applications thermal behaviour, mode of polymerization. Concept of average molecular weight of polymers, molecular weight distribution, poly disparity index, determination of average molecular weights: End group analysis, Osmometry, light scattering techniques, viscometer, Gel permeation chromatography.

**UNIT-II**

**Natural polymers:**brief study of Natural rubber, Shellac, Rosin, Cellulose, Proteins
**Degradation of polymers, Role of the following additives in the polymers:**
i) Fillers and reinforcing fillers ii) Plasticizers iii) Lubricants iv) Antioxidants and UV stabilizers v) Blowing agents vi) Coupling agents vii) Flame retardants viii) Inhibitors

**UNIT-III**

**Mechanism and kinetics of:** Addition or chain polymerization, free radical addition polymerization, ionic addition polymerization, coordination polymerization, coordination or step growth or condensation polymerization.
**Compounding of polymer resins. Brief description of:** I Compression and transfer moulding ii) Injection moulding iii) Extrusion IV) Blow moulding v) calendaring vi) Laminating and pultrusion.

**UNIT-IV**

**Methods of polymerization:** mass or bulk polymerization process, solution polymerization process, suspension polymerization process and emulsion polymerization method comparison of merits and demerits of these methods. Properties of polymers: crystalline and amorphous status, melting and glass transition temperature and their determination, effect of polymer structure on mechanical, physical chemical and thermal properties.

**UNIT-V**

**Brief description of manufacture, properties and uses of:**

i) Polyethylene (HDRP &LDPE) ii) Poly propylene iii) polyvinylchloride iv) polystyrene v) polytetra fluroethylene vi) poly methyl mehacrylate vii) polyvinyl acetate &polyvinyl alcohol viii) Epoxyphenolic Resins ix) FRP's(Fibre Reinforced Plastics) with polypropylene.

**COURSE OUTCOMES: Students will able to**

1. Understand mechanism and mathematical modeling of different types of polymerizations.
2. Understands the natural polymers and their importance
3. Understands the mechanism and kinetics involved in polymerization.
4. Understands the methods of polymerization.
5. Understands degradation of polymers and role of additives in polymers.

**TEXTBOOKS:**

1. Polymer Science &Technology 2nd ed., J.R.Fried, PHI Learning Pvt. Ltd. New Delhi, 2009.

2. Plastic materials, J.A Bryson, Newnes-Butterworth (London), 1989.

**REFERENCES:**

1. Text book of polymer science, F.W. Jr.Bill Meyer , (3rd ed.,) John Wiley & sons 1984.

2. Introduction to plastics .J.H Brison and C.C Gosselin, Newnes-Butterworth , London 1968.

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## CORRSOSION ENGINEERING

**Prerequisite:** Engineering Physics and Chemistry, Material Science for Chemical Engineers

**COURSE OBJECTIVES:**

1. To introduce the principles of corrosion, material selection, and metallurgical aspects..
2. To introduce different types of corrosion and factors affecting them.
3. To introduce different methods of corrosion testing procedures.
4. To learn different protection measures against corrosion.
5. To enable students to understand the thermodynamics involved in corrosion.

**UNIT – I**

**Introduction:** Corrosion principles, Types of Corrosion, Acid Theory, Dry chemical corrosion, Wet theory or Electrochemical Theory, Electro- chemical aspects of Corrosion, - environmental effects, Pilling Bedworth Rule, Metallurgical aspects- corrosion rate expressions- methods of estimation of corrosion rates, Passivity.

**UNIT –II**

**Types of corrosion:** Forms of corrosion, uniform attack, galvanic corrosion, Examples of galvanic corrosion, Factors affecting galvanic corrosion, Crevice corrosion, Types of Crevice corrosion, pitting Corrosion: Principle and Theory, inter —granular corrosion, Knife line attack, selective leaching: Dezincification and Graphitization, Cavitation damage, Fretting Corrosion.

**UNIT – III**

Erosion- corrosion and some case studies, Factors affecting erosion- corrosion, stress corrosion cracking and Factors affecting stress corrosion.
**Corrosion testing procedures:** Introduction, Purpose of Testing, Steps involved in Corrosion testing, Standard expression for corrosion rate, NACE test, Slow stain rate test, Linear Polarization, Paint test, Seawater test, In vivo corrosion test (Field test).

**UNIT – IV**
**Protection against Corrosion:** Material selection, alteration of environment, Use of inhibitors, Protection by proper Designing, Modification of the properties of the metal,

Cathodic Protection and Anodic Protection Units, Use of protective coatings -organic and inorganic coatings, Methods of application of metallic coatings, cladding. Introduction to FRP's(Fibre reinforced plastics), Properties and applications of FRP's.

**UNIT–V:**

**Modern Theory**: Principle, Thermodynamics: Free energy, Cell Potential, SHE and EMF series, Application of Thermodynamics to corrosion, Pourbaix Diagram. Electrode Kinetics: Exchange current density, Activation Polarization, Concentration Polarization, Combined Polarization, Mixed electrodes, Passivity with modern aspects.

**Predicting corrosion behavior:** Effect of oxidizers, Velocity effects, galvanic coupling, Alloy evaluation. Corrosion prevention: Anodic Protection and Noble-Metal Alloying.

**COURSE OUTCOMES:**

1. Ability to understand electrochemical fundamentals
2. Ability to understand different types of corrosion.
3. Ability to understand different corrosion testing procedures.
4. Ability to understand corrosion preventing methods
5. Ability to understand application of thermodynamics to corrosion.

**TEXT BOOKS**:

1. Corrosion Engineering, 3rd ed., M.G. Fontana, Tata Mc Graw Hill, 2005.

**REFERENCES:**

1. Corrosion and Corrosion Control, H.H Uhlig, Wiley, 3rd edition, 2011.
2. Handbook of Corrosion Engineering, Pierre Roberge, Mc Graw- Hill, New York, 2000.

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## ENVIRONMENTAL POLLUTION AND CONTROL

**PRE REQUISITES**: Mass Transfer operations, mechanical unit operations

**COURSE OBJECTIVES: Students able to learn about**

1. Different types of wastes generated in an industry, their effects on living and non-living things.
2. Various air sampling methods and collection of particulates
3. Different control devices.
4. The quantification and analysis of wastewater and treatment
5. The solid waste Recycling and Recovery

**UNIT- I**

Introduction: Types of Emissions from Chemical industries: and effects of Environment, environment legislation, types of pollution, sources of Waste water, Effluent guide lines and standards. Characterization of effluent streams, oxygen demands and their determination (BOD,COD, TOC,) Oxygen sage curve, BOD curve mathematical, controlling of BOD curve, self-purification of running streams, sources and Characteristics of pollutants in petroleum, paper & pulp fertilizer industry.

**UNIT II**

**Air pollution sampling and measurement**: Types of pollutant and sampling and measurement, ambient air sampling, collection of gaseous air pollutants. Collection of particulate air pollutants. Stack sampling: sampling system, particulate sampling and gaseous sampling. Analysis of air pollutants: sulphur dioxide, nitrogen oxides, carbon monoxide, oxidants and Ozone, hydrocarbons, particulate matter. General methods of control and removal of $S0_2$, Oxides of nitrogen and organic vapors from gaseous effluent.

**UNIT III**

**Air pollution control methods and equipment's**: Source collection methods, raw material changes, equipment modification. Cleaning of gaseous equipment's particulate emission control: collection efficiency, control equipment like gravitational settling chambers, Cyclone separators, fabric filters, ESP and their constructional details and design.

Scrubbers: wet scrubbers, Spray towers, centrifugal scrubbers, packed beds and plate columns, venturi scrubbers, their design aspects .Control of gaseous emissions: Absorption by liquids and solids, absorption equipment and their design aspects.

**UNIT -IV**

**Biological treatment of waste waters** – aerobic and anaerobic methods – suspended and attached growth processes – bacteria – Reproduction in bacterial – Bacterial growth crushes, conventional activated sludge process – Trickling filters, Aerated lagoons – stabilization ponds,– fluidized bed contractors.**Physical Treatment methods** : Principle and working of screening – sedimentation – flotation – filtration – flocculation, Tertiary Treatment methods – carbon adsorption – lon exchange – Reverse Osmosis, Ultra filtration, Sludge treatment and disposal .

**UNIT –V**

**Solid waste management:** Sources and classification ,methods of Collection, ,incineration,comdisposal methods:composting ,open dumping, sanitary landfilling and incineration.potential methods of disposal:utilization, Recovery and recycling

**COURSE OUTCOMES:**

1.Student able to Understand the different types of wastes generated in an industry, their effects on living and non-living things.

2.Students can analyse the various air sampling methods and collection of particulates

3.Students will able Discuss and design the different control devices.

4.Understand about the quantification and analysis of wastewater and treatment

5.Students can able to understand the solid waste Recycling and Recovery

**TEXT BOOKS:**

1.Pollution control in process industries by S.P. Mahajan TMH.,1985

2.Environmental pollution and control engineering by Rao C. S. –Wiley Eastern Limited, India, 1993.

**REFERENCES**

1.Waste water treatment by M.Narayana Rao and A.K.Datta, Oxford and IHB publisher, New Delhi

2. Air pollution control by P.Prathap mouli and N.Venkata subbayya. Divya Jyothi Prakashan, Jodhpur.

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## INDUSTRIAL SAFETY AND HAZARD MANAGEMENT

**Prerequisite:** Environmental Studies

**COURSE OBJECTIVES:**

This course will provide

1. Effective use of chemical industry utilities.
2. Emphasis on the knowledge of loss prevention
3. Knowledge about personal safety and industrial safety.
4. To determine the hazard analysis and the toxicology.
5. A importance of Personal proactive equipment's used in industries

**UNIT I**

**Introduction:**

Safety program, Engineering ethics, Accident and loss statistics, Acceptable risk, Public perception, Toxicology: How toxicants enter biological organisms, how toxicants are eliminated from biological organisms.

**UNIT II**

**Industrial Hygiene:**

Government regulations, Identification: material safety data sheets, Evaluation: evaluating exposures to volatile, Control: respirators, ventilation.

**UNIT III**

**Fires and Explosions:**

The fire triangle, Distinction between fire and explosions: Definitions, Flammability characteristics of liquids and vapors, MOC and inerting, ignition energy, Auto ignition, Auto oxidation, adiabatic compression, Explosions.

**Designs to prevent fires and Explosions:**

Inerting, Explosion proof equipment and instruments, Ventilations, Sprinkler systems. Hazards Identification: Process hazards checklists, Hazard surveys, and Hazop safety reviews.

**UNIT IV**

**Introduction to Reliefs**: Relief concepts: Definitions, Location of reliefs, Relief types, Data for sizing reliefs, Relief systems. **Relief Sizing**: Conventional spring operated reliefs in liquids, Conventional spring operated relief's in vapor or gas service, Rupture disc relief's in liquid, vapor or gas service.

**UNIT V**

**Chemical Process Safety:** Introduction, Chemical process in Hazardous operations, chemical reactors, Reaction Hazards, Operational Deviations and Technical Report.

**Personal Protective Equipment:** Introduction ,Legal Requirements , Selection guide lines, Head Protection, Eye and Face Protection , Hand Protection ,Foot and Leg Protection, Body Protection, Indian standards on Personal Protective Equipment.

**COURSE OUTCOMES: Students will able to**

1. Understanding of Safety principles and toxicology
2. Identify and evaluate the different types of Hazard analysis.
3. Analyse and take preventive measure of Fire & explosions industrial hazards and accidents.
4. Apply the relief system for different types of valves in industries and statistical analysis of accidents.
5. Acquire knowledge of accident investigation and Personal Protective Equipments.

**TEXT BOOKS:**

1. Chemical Process Safety – (Fundamentals with applications), D.A.Crowl & J.F.Louvar Prentice Hall, New Jersey, 1990.
2. Industrial Hygiene and Chemical safety –M.H.Faulekar, I.K. International, 2006.

**REFERENCES:**

1. Safety and Accident Prevention in Chemical Operations, H.H.Fawcett and W.S.Wood, 2nd Edition, John Wiley and sons, New York, 1982.
2. Coulson and Richardson's – Chemical engineering – R.K.Sinnot, Vol.6, Butterworth-Heinmann Limited, 1996.

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# PETROLEUM AND PETROCHEMICAL TECHNOLOGY

**PREREQUISITE:** Mechanical Unit Operations, Chemical Technology, Heat Transfer, Mass Transfer Operations.

**COURSE OBJECTIVES:**
Studying this subject the students will learn about

- The Distillation and extraction operations
- Production of oil and gas to meet energy needs
- Treatment techniques for different fraction of petroleum
- Refining of crude oil for a wide spectrum of useful products
- Various products of Petrochemicals, Chemicals, Plastics.

**UNIT I:**

**Origin formation and composition of petroleum**: Origin and formation petroleum, Reserves and deposits of world, Indian petroleum Industry.
**Petrochemical industry-** feedstocks.

**UNIT–II:**

**Petroleum processing data:** Evaluation of petroleum, Thermal properties of petroleum Fractions, important products properties and test methods.
**Fractionation of Petroleum:** Dehydration and desalting of crudes, heating of crude pipes still heaters, distillation of petroleum, blending of gasoline.

**UNIT III:**

Treatment techniques: Fraction-impurities, treatment of gasoline, treatment of kerosene, treatment of lubes.

**UNIT IV:**

**Thermal and catalytic processes**: cracking, catalytic cracking, catalytic forming, Naptha cracking, coking, Hydrogenation processes, Alkylation processes, Isomerization Process.
**Chemicals from Methane**: Introduction, production of methanol, formaldehyde ethylene glycol, **PTFE,** methylamines.

**UNIT V:**

**Chemicals from Ethane-Ethylene –**Acetylene: Oxidation of ethane, production of Ethylene, Manufacture of Vinyl Chloride monomer, Vinyl Acetate manufacture, Ethanol from Ethylene, Acetylene Manufacture, Acetaldehyde from Acetylene.

**COURSE OUTCOMES: Students able to**

1. Understand the various feed stocks of refinery and petroleum products in India.
2. Categorize with basic fractionation and conversion processes used in refining of crude oil.
3. Identify the challenges involved in treatment techniques from viewpoint of environment.
4. Apply the various thermal catalytic processes used to produce various petroleum products
5. Acquainted with technologies used for manufacturing petroleum products at commercial scale.

**TEXT BOOKS:**

1. Modern Petroleum Refining Processes, 5th ed., B.K Bhaskara Rao, Oxford and IBH Publishing, 2007
2. Petroleum Refining Engineering, 4th ed., WL Nelson, McGraw Hill, New York, 1958.

**REFERENCES:**

1. Shreve's chemical Process industries, 5th ed., G.T Austin, Mc Graw –Hill, New York, 1984.
2. Chemical Technology of petroleum .W.S.Gruese and D.R Stevens, Mc Graw –Hill 1980.

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## PULP AND PAPER TECHNOLOGY

**PREREQUISITE:** Mechanical Unit Operation, Chemical Technology

**COURSE OBJECTIVES:**

To provide the basic concepts of pulp and paper manufacturing process to the chemical engineering students
which will enable them to understand and acquire knowledge in pulp and paper sector.

1. To introduce the basic pulp and papermaking processes from virgin and recycled raw materials.
2. Acquaint students with raw material characteristics, physical and mechanical concepts, nomenclature and procedures related to evaluating paper and paper board product properties
3. To provide an understanding of the conversion of wood to mechanical and chemical pulps (Craft, sulphite, and semi-pulping processes). Chemical recovery systems and bleaching of mechanical pulps.
4. Provide fundamental knowledge necessary to maximize bleach plant performance while extending the life span of pulp/bleaching equipment.
5. Recognize the complex environmental challenges the pulp and paper industry faces.

**UNIT I**

INTRODUCTION: Pulp and Paper Industry Scenario in India, Chronological development of pulp and paper technology, Definitions of pulp and paper, Flow sheet of complete pulp and paper manufacturing process

**UNIT II**

RAW MATERIAL SELECTION: Types of wood – softwood, hardwood and non-wood, composition of wood- cellulose, hemicelluloses, lignin, extractives, and inorganic components, comparison with other raw materials

**UNIT III**

PULPING PROCESS: Pulping processes – Mechanical Pulping, Kraft Pulping, Sulphite Pulping, Cooking equipment, washing, screening and thickening, Stock Preparation

**UNIT IV**

Chemical Recovery Black liquor oxidation, Recaustizing, Calcining, Alternate Kraft recovery systems

**UNIT V**

PAPER MACHINE: Introduction to paper machine, Wet and dry end operations, finishing, properties and testing of paper, end uses of paper

**COURCE OUTCOMES:**

**The student will be**

1. Able to handle pulp and paper processes affect product quality and learn to troubleshoot variations to improve quality.
2. Optimize pulping operations to achieve maximum pulp bleachability and strength properties
3. Apply the fundamental chemical principles of making pulp and paper in the industry.
4. Advice pulp and paper makers on how to control environmental pollution.
5. Identify requirements for process control and quality assurance in pulp and paper manufacturing processes.

**TEXT BOOKS**

1. Smook. G. A, “Hand book for Pulp and Paper Technologists”, 7 th Edn., TAAPI Press 1989
2. Mc Donald. R. G,. and Franklin J. N. Pulp and Paper Manufacture” Vol 2. Mc Graw Hill. 1969.

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## MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS

**Course Objectives:**

1. To explain the fundamentals of the key elements of a business organization.
2. To learn practical approach to various functional areas of decision making.
3. To Compare different Pricing Strategies.
4. To enhance a knowledge of Capital Budgeting Techniques.
5. To solve the problems using Rations analysis.

**UNIT – I**

**Introduction to Managerial Economics:** Definition, Nature and scope of Managerial Economics, Demand Analysis- Demand Determinants, Law of Demand and its exceptions.

**Elasticity of Demand:** Definition, Types, Measurement and Significance of Elasticity of Demand. Demand Forecasting, Methods of Demand Forecasting (Survey Methods, Statistical Methods, Expert Opinion Method, Test Marketing, Controlled Experiments, Judgmental Approach to Demand Forecasting)

**UNIT – II**

**Theory of Production and Cost Analysis:** Production Function – Isoquants and Isocosts, MRTS, Least Cost Combination of Inputs.

**Cost Analysis:** Cost concepts, Opportunity Cost, Out of Pocket Costs vs. Imputed Costs. Breakeven Analysis (BEA) – Determination of Breakeven Point (simple problems), Managerial Significance and limitations of BEA.

**UNIT – III**

**Market Structures& Pricing Policies:**

**Market structures:** Types of Competition, Features of Perfect Competition, Monopoly and Monopolistic Competition, Price - Output determination in Perfect Competition and monopoly.

**Objectives and Policies of Pricing:** Objectives of pricing**,** Methods of Pricing - Cost Plus Pricing, Marginal Cost Pricing, Sealed Bid Pricing, Going Rate Pricing, Limit Pricing, Market Skimming Pricing, Penetration Pricing, Two - Part Pricing, Block Pricing, Peak Load Pricing, Cross Subsidization.

**UNIT – IV**

**Introduction to Financial Accounting:** Accounting, Double-Entry Book Keeping, Journal, Ledger, and Trial Balance, Final Accounts (Trading Account, Profit and Loss Account and Balance Sheet with simple adjustments).

**UNIT – V**

**Financial Analysis through ratios:** Computation, Analysis and Interpretation of Liquidity Ratios (Current Ratio and Quick Ratio), Activity Ratios ( Inventory Turnover Ratio and Debtor Turnover Ratio), Capital Structure Ratios ( Debt – Equity, Interest Coverage Ratio), and Profitability Ratios (Gross Profit Ratio, Net Profit Ratio, Operating Profit Ratio, P/E Ratio and EPS).

**Course Out comes: At the end of the course, students will be able to**

1. Describe the concept of demand and its determinants in Managerial decisions.
2. Analyze the cost concepts and breakeven analysis in production.
3. Evaluate the market structures and different Pricing Strategies.
4. Apply the capital budgeting techniques in financial decisions.
5. Application of Ratios in solving of business problems and taking correct decisions.

**TEXT BOOKS:**

1. Varshney & Maheshwari, Managerial Economics, Sultan Chand& Sons, 2014.
2. S.A. Siddiqui and A.S. Siddiqui, Managerial Economics and Financial Analysis, New Age International Publishers, Hyderabad, 2013

**REFERENCES:**

1. R. K. Sharma & Shashi K Gupta, Financial and Management Accounting, 4th Ed., Sultan Chand.
2. V. Rajasekaran & R. Lalitha, Financial Accounting, Pearson Education, New Delhi, 2010.

3. Domnick Salvatore, Managerial Economics in a Global Economy, 4th Edition, Cengage, 2009.
4. Subhash Sharma & M. P. Vittal, Financial Accounting for Management, Text & Cases, Machmillan, 2012.
5. S. N. Maheshwari & S. K. Maheshwari, Financial Accounting, Vikas 2012.
6. Truet and Truet, Managerial Economics; Analysis, Problems and Cases, Wiley, 2012.
7. Dwivedi, Managerial Economics, Vikas 2012.
8. M. Kasi Reddy and S.Saraswathi, Managerial Economics and Financial Accounting, PHI, 2012.
9. Erich A. Helfert, Techniques of Financial Analysis, Jalco, 2007.

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## NUMERICAL METHODS IN CHEMICAL ENGINEERING

**Prerequisites: Engineering Mathematics – I and II**

**COURSE OBJECTIVE:** Students will able learn about

1. Various numerical methods involved in solving the algebraic equations.
2. ODEs and PDEs and their applications in chemical engineering domain.
3. Interpolation and Approximation.
4. Numerical integration Trapezoidal rule, Simpson's rules.
5. Euler method, Runge-Kutta method.

**UNIT I**
Introduction, Approximation and Concept of Error & Error Analysis. Linear Algebraic Equations: Methods like Gauss elimination, LU decomposition and matrix inversion, Gauss-Siedel method, Chemical engineering problems involving solution of linear algebraic equations

**UNIT II**
Root finding methods for solution on non-linear algebraic equations: Bisection, Newton-Raphson and Secant methods, Chemical engineering problems involving solution of non-linear equations

**UNIT III**
Interpolation and Approximation, Newton's polynomials and Lagrange polynomials, Spline interpolation, linear regression, polynomial regression, least square regression

**UNIT IV**
Numerical integration: Trapezoidal rule, Simpson's rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration

**UNIT V**
Ordinary Differential Equations: Euler method, Runge-Kutta method, Adaptive Runge-Kutta method, Initial and boundary value problems, Chemical engineering problems involving single, and a system of ODEs ,Introduction to Partial Differential

Equations: Characterization of PDEs, Laplace equation, Heat conduction/diffusion equations, explicit, implicit, Crank-Nicholson method.

**OUTCOME:** Upon the successful completion of the course, the student will be able to:

1. Understand the mathematical techniques used for engineering applications
2. Formulate mathematically the given physical system
3. Apply the knowledge of mathematical tools to simulate chemical engineering systems
4. Familiar with various numerical techniques for integration and differentiation.
5. Apply the various tools for differential equations that come across in chemical engineering

**TEXTBOOKS:**

Gupta, S. K., "Numerical Methods for Engineers", New Academic Science, 2012.

**REFERENCES:**

1. S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
2. R.L. Burden & J. D. Faires, "Numerical Analysis", 7th Ed., Brooks Coles, 2000.
3.Atkinson, K. E., "An Introduction to Numerical Analysis", John Wiley & Son

4. W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

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## NUMERICAL METHODS I N CHEMICAL ENGINEERING LAB

**COURSE OBJECTIVE: Students will able to**

1. Solve engineering problems in general and chemical engineering problems in specific.
2. Solve PDEs using Euler method.
3. Solve ODEs using simple numerical methods.
4. Perform numerical integration using computational techniques.
5. Solve non-linear equations using bracketing and Newton-Raphson method

(At least **Ten** experiments out of the following twelve experiments should be performed)

**List of Experiments:**

The following experiments have to be conducted using MATLAB/C.

1. Introduction to use of computers for numerical calculations.
2. Solution of linear algebraic equations using Gauss Elimination etc.
3. Solution of linear algebraic equations using Gauss-Siedel method.
4. Solution of non-linear equations using bracketing and Newton-Raphson method.
5. Exercises involving Interpolation and Approximation.
6. Numerical integration.
7. Solution of ODEs using Euler method.
8. Solution of ODEs using Runge-Kutta methods.
9. Solution of simple PDEs.
10. Dew Point and Bubble point Calculations
11. Vander waals equation of state
12. Ideal Gas Equation

Major requirements are Personal Computer and MATLAB Software

**TEXTBOOKS:**

Gupta, S. K., "Numerical Methods for Engineers", New Academic Science, 2012.

**COURSE OUTCOME:**

Student will be able to:

1. Explore the basic knowledge on computational techniques.
2. Apply the computational techniques to solve linear algebraic equations.
3. Realize the use of computational techniques to solve linear algebraic equations.
4. Perform numerical integration using computational techniques.
5. Solve ODEs using simple numerical methods.

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## Advanced English Communication skills Lab

### 1. Introduction

The introduction of the English Language Lab is considered essential at 3rd year level. At this stage the students need to prepare themselves for their careers which may require them to listen to, read, speak and write in English both for their professional and interpersonal communication in the globalised context.

The proposed course should be an integrated theory and lab course to enable students to use 'good' English and perform the following:

- Gather ideas and information, to organise ideas relevantly and coherently.
- Engage in debates.
- Participate in group discussions.
- Face interviews.
- Write project/research reports/technical reports.
- Make oral presentations.
- Write formal letters.
- Transfer information from non-verbal to verbal texts and vice versa.
- To take part in social and professional communication.

### 2. Objectives:

This Lab focuses on using computer-aided multimedia instruction for language development to meet the following targets:

- To improve the students' fluency in English, through a well-developed vocabulary and enable them to listen to English spoken at normal conversational speed by educated English speakers and respond appropriately in different socio-cultural and professional contexts.
- Further, they would be required to communicate their ideas relevantly and coherently in writing.

1. **Vocabulary Building** – synonyms and antonyms, Word Roots, One-Word Substitutes, Prefixes and Suffixes, Study of Word Origin, Analogy, Idioms and Phrases.
2. **Reading Comprehension –** Reading for Facts, Guessing meanings from context, Scanning, Skimming, Inferring Meaning, and Critical Reading.
3. **Writing Skills** –Structure and presentation of different types of writing - Resume Writing /E-Correspondence/Statement of Purpose.
4. **Technical Writing**- Technical Report Writing, Research Abilities/Data Collection/Organizing Data/Tools/Analysis.
5. **Group Discussion** – Dynamics of Group Discussion, Intervention, Summarizing, Modulation of Voice, Body Language, Relevance, Fluency and Coherence.
6. **Presentation Skills** – Oral presentations (individual and group) through JAM sessions/Seminars, Written Presentations through Projects/ PPTs/e-mails etc.
7. **Interview Skills** – Concept and Process, Pre-Interview Planning, Opening Strategies, Answering Strategies, Interview through Telephone and Video-Conferencing.

**Suggested Software:**

The software consisting of the prescribed topics elaborated above should be procured and used.

- Clarity Pronunciation Power – part II 
- Oxford Advanced Learner‘s Compass, 7th Edition 
- DELTA‘s key to the Next Generation TOEFL Test: Advanced Skill Practice.
- Lingua TOEFL CBT Insider, by Dreamtech.
- TOEFL & GRE( KAPLAN, AARCO & BARRONS, USA, Cracking GRE by CLIFFS) 
- The following software from _train2success.com‘ 
  i. Preparing for being Interviewed,
  ii. Positive Thinking,
  iii. Interviewing Skills,
  iv. Telephone Skills,
  v. Time Management
  vi. Team Building,
  vii. Decision making
- English in Mind, Herbert Puchta and Jeff Stranks with Meredith Levy, Cambridge 

**Text Books:**

1. Technical Communication by Meenakshi Raman & Sangeeta Sharma, Oxford University Press 2009.
2. Advanced Communication Skills Laboratory Manual by Sudha Rani, D, Pearson Education 2011.
3. English Language Communication : A Reader cum Lab Manual Dr A Ramakrishna Rao, Dr G Natanam & Prof SA Sankaranarayanan, Anuradha Publications, Chennai 2008.
4. English Vocabulary in Use series, Cambridge University Press 2008.
5. Management Shapers Series by Universities Press(India)Pvt Ltd., Himayatnagar, Hyderabad 2008.
6. Communication Skills by Leena Sen, PHI Learning Pvt Ltd., New Delhi, 2009.
7. Handbook for Technical Writing by David A McMurrey & Joanne Buckely CENGAGE Learning 2008.
8. Job Hunting by Colm Downes, Cambridge University Press 2008.
9. Master Public Speaking by Anne Nicholls, JAICO Publishing House, 2006.
10. English for Technical Communication for Engineering Students, Aysha Vish hwamohan, Tata Mc Graw-Hil 2009.
11. Books on TOEFL/GRE/GMAT/CAT/ IELTS by Barron‘s/DELTA/Cambridge University Press.
12. International English for Call Centres by Barry Tomalin and Suhashini Thomas, Macmillan Publishers, 2009.

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## CHEMICAL REACTION ENGINEERING-II

**PREREQUISITE:** Chemical Reaction Engineering-1

**COURSE OBJECTIVES:**

1. To provide students through understanding of reaction Engineering applications.
2. Apply the Knowledge of reaction engineering in design of a reactor dispersing model Tanks – in-series model.
3. To understand and identify floe to be non – ideal.
4. To understand causes of non- ideal flow and tank into accent of non- ideality in design of reactor
5. To study and apply mechanism of catalyst deactivation.

**UNIT-I**

Basics of non-ideal flow-E, the age distribution of fluid, the RTD, Conversion in Non-ideal flow reactors, diagnosing reactor ills (qualitative discussion only).The dispersion model-axial dispersion, correlation for axial dispersion, chemical reaction and dispersion.

**UNIT-II**

The tanks-in-series model-pulse response experiments and RTD, chemical conversion. The convection model for laminar flow-the convective model and its RTD, chemical conversion in laminar flow reactors.

Earliness of mixing, segregation and RTD-self mixing of a single fluid, mixing of two miscible fluids.

**UNIT-III**

Catalysis and catalytic reactors-catalysts, steps in catalytic reactions, synthesizing a rate law, mechanism and rate limiting step (From chapter-10 Fogler). Heterogeneous reactions-Introduction.

Solid catalyzed reactions-The rate equation for surface kinetics-Pore diffusion resistance combined with surface kinetics, Porous catalyst particles, Heat effects during reactions, Performance equations for reactors containing porous catalyst particles.

**UNIT-IV**

Solid catalyzed reactions-Experimental methods for finding rates, Deactivating catalysts-Mechanisms of catalyst deactivation, the rate and performance equations.

**UNIT-V**

Fluid-fluid reactions-Kinetics-the rate equation. Fluid particle reactions: Kinetics-Selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, extensions, determination of rate controlling steps.

**COURSE OUTCOMES: Students will be able to**

1. Develop rate laws for use in reactor design based on reaction data from a reactor or set of reactors.
2. Make comparisons of ideal reactor types (batch, plug flow, mixed flow, etc.) and be able to determine the best choice for simple objectives when using a single reactor or a set of reactors.
3. Predict reactor performance in situations where a reacting gas has a significantly changing density, including the case of variable pressure within an ideal plug flow reactor.
4. Determine optimal ideal reactor design for multiple reactions for yield or selectivity
5. Determine the Catalysis and catalytic reactors

**TEXT BOOK:**

1. Chemical reaction engineering by Octave Levenspiel, 3rd ed. John Wiley and Sons, 1990.

**REFERENCES:**

1. Elements of Chemical reaction engineering by H.S. Fogler, 2nd ed.PHI, 1992.
2. Chemical engineering Kinetics by J.M. Smith, 3rd ed.Mc Graw Hill,1981.

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### MASS TRANSFER OPERATION-II

**PREREQUISITE:** Mass Transfer-1

**COURSE OBJECTIVES:**
The objective of this course is

1. To study the separation techniques in the process industry, and provide proper understanding of unit operations
2. Study of the stage wise mass transfer operations, principles of various stage wise contact processes like distillation, extraction and leaching and adsorption operations.
3. Design aspects of the equipments utilized for distillation, extraction and adsorption operations.
4. Attain practical knowledge of separation processes, conduct experiments and submit the report.
5. To Understand membrane-based separation processes and Ability to analyze and design membrane separation systems.

**UNIT-I**
Distillation: Fields of applications, VLE for miscible liquids, immiscible liquids, Positive and negative deviations from ideality, enthalpy-concentration diagrams, flash vaporization and differential distillation for binary and multi component mixtures, Azeotropic distillation, extractive distillation, steam distillation

**UNIT-II**
Continuous rectification-binary systems, multistage tray towers –method of Mc Cabe and Thiele, enriching section, exhausting section, feed introduction, total reflux, minimum and optimum reflux ratios, use of open steam, condensers, partial condensers, cold reflux, multiple feeds , tray efficiencies, continuous-contact equipment(packed towers)
Multistage (tray) towers –the method of Ponchon and Savarit, the enriching and stripping sections, feed tray location, total reflux, minimum and optimum reflux ratios, reboilers, use of open steam, condenser and reflux accumulators.

**UNIT-III**
Liquid-Liquid operations: fields of usefulness, liquid-liquid equilibrium, equilateral triangular co-ordinates, system of three liquids, choice of solvent, stage wise contact, multistage cross-current extraction, Multi stage counter current without reflux and with reflux, fractional

extraction, Differential (continuous contact) extractors, spray towers, packed towers, mechanically agitated counter-current extractors, centrifugal extractors, dilute solutions.
Leaching: Fields of applications, preparation of solid for leaching, types of leaching, leaching equilibrium, single stage and multi stage leaching calculations, constant under flow conditions, equipment for leaching operation.

**UNIT-IV**
Adsorption: Types of adsorption, nature of adsorbents, adsorption equilibrium, single gases and vapors, Adsorption Hysteresis, effect of temperature, Heat of adsorption, Adsorption of solute from dilute and concentrated solutions, stage wise operation, application of Freundlich equation to single and multistage adsorption (cross current & counter current).

Adsorption of vapor from a gas, fluidized bed, steady state moving bed adsorbers, unsteady state–fixed bed adsorbers, adsorption wave, rate of adsorption in fixed bed, principles of ion exchange, rate of ion exchange.

**UNIT-V**
**Introduction to Membrane Separation:** Introduction and types of membrane separation processes, liquid permeation membrane processes, Solid permeation membrane processes, complete mixing models for gas separations by membranes and multi-component mixtures, cross flow model for gas separation by membranes, Derivation of equations for counter-current and co-current flow for gas separation for membranes, Reverese osmosis , Ultrafiltration, micro filtration membrane processes, Applications , equipment, models for reverse osmosis.

**COURSE OUTCOMES:**
**The student will be**
1. To select the modern separation technique in various applications and apply the mass transfer concepts in the design of separation columns.
2. Able to operate simple, steam, fractional ,steam , azeotrophic and extractive distillation
3. Ability to design and operate the unit operations like distillation, adsorption, liquid-liquid extraction, leaching.
4. Construct and analyze a multi-stage equilibrium separation processes.
5. Student can develop different flow model equations for membrane separation processes.

**TEXT BOOKS:**
1. Mass transfer operations by R.E. Tryebal, 3rd ed. Mc Graw Hill, 1980.
2. W.L. McCabe, J. Smith and P. Harriot, Unit Operations of ChemicalEngineering, 7th Edition, Tata McGraw Hill, India, 2014.

**REFERENCES:**

1. Diffusion: Mass Transfer in Fluid System by E. L. Cussler, 2009.
2. Transport processes and Separation Process Principles 4th Ed., by Christie J. Geankoplis, PHI Learning Pvt. Ltd., New Delhi, 2009
3. Binay K.Dutta, Principles of Mass Transfer and Separation Processes,2nd edition, Prentice Hall of India,2007

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## PLANT DESIGN AND ECONOMICS

**Prerequisite:** Chemical Process Calculations, Process Modelling and Simulations

**COURSE OBJECTIVES:** By studying this subject students will learn about

1. Principles of cost estimation,
2. Feasibility analysis of plant location
3. Management, organization and quality control that will enable the students to perform as efficient managers.
4. Interest and investment cost
5. Profitability, Alternative investments and Replacements

**UNIT I**

Introduction, Process design development, General design considerations, cost and asset accounting, in detail case study for nitric acid and sodium dodecylbenzene sulfonate. Cash flow for industrial operations, factors effecting investment and production cost, capital investments, estimation of capital investments, cost indices, cost factors in capital investment.

**UNIT II**

Organization for presenting capital investments, estimates by compartmentalization, estimation of total product cost direction, Production costs, fixed charges, plant overhead costs, financing.

**UNIT III**

Interest and investment cost, types of interest, nominal and effective interest rates, continuous interest, present worth and discount annuities, cost due to interest on investment, source of capital, Taxes and insurances, type of taxes: Federal income taxes, insurance-types of insurances, Self-insurance.

Depreciation: types of Depreciation, service life, salvage value, Present value, Methods for determining depreciation, single unit and group depreciation.

**UNIT– IV**

Profitability: Alternative investments and Replacements, profitability standards, Discounted cash flow, Capitalized cost, pay-out period, Alternative investments, analysis with small investments, increments and replacements.

**UNIT V**

Optimum design and Design strategy, incremental cost, general procedure for determining optimum condition, comparison of graphical and analytical methods, optimum production rates, semi continuous cyclic operation, fluid dynamics, mass transfer strategy of linearization.

**COURSE OUTCOMES: Students will able to**

1. Learn basics of Cost estimation, Working Capital and Capital Investment and understand the time value of money
2. Study depreciation methods and learn tax calculation methods
3. Learn the methods of estimation of profitability of an industry and procedures adopted for Replacement and Selection from Alternatives.
4. Understand process equipment design concept perform various optimize various parameters such as heat duty of heat exchanger, production rate of various process plants.
5. Understand the Optimum pipe Dia

**TEXT BOOKS:**

1. Plant Design and Economics for Chemical Engineering, 4th ed, M.S. Peters and K.D. Timmerhaus, Mc Graw-Hill, 1991.
2. Process Engineering Economics, H.E. Schweyer, Mc Graw Hill Co., New York, Kogakusha Co., Ltd., Tokyo. 1955.

**REFERENCES:**

1. Chemical Engineering plant Design by C.Vilbrandt and Dryden C.E. 4th Edition, Mc Graw Hill Book Co., 1959.

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## NANO SCIENCE AND NANOTECHNOLOGY

**Prerequisite:** Engineering Physics

COURSE OBJECTIVES: This course will

1. Provide the most exciting and novel properties at nanoscale regime
2. Explain the interdisciplinary issues in nanoscale science and technology.
3. Discuss about the basics of nanotechnology
4. Classify and explain the various properties of nanomaterials
5. Describe the various methods for synthesis of nanomaterials and their applications

**Unit I: Introduction:** History and Scope, Can Small Things Make a Big Difference? Quantum confinement, Surface area to Volume ratio, Classification of Nanostructured Materials, Fascinating Nanostructures, Applications of Nanomaterials, Nature: The Best of Nanotechnologist, Challenges and Future Prospects.

**Unit II: Unique Properties of Nanomaterials: Microstructure and Defects in Nanocrystalline Materials**: Dislocations, Twins, stacking faults and voids, Grain Boundaries, triple and disclinations. **Effect of Nano-dimensions on Materials Behavior:** Elastic properties, Melting Point, Diffusivity, Grain growth characteristics, enhanced solid solubility. **Magnetic Properties**: Soft magnetic nanocrystalline alloy, Permanent magnetic nanocrystalline materials, Giant Magnetic Resonance, Electrical Properties, Optical Properties, Thermal Properties and Mechanical Properties.

**Unit III: Synthesis Routes: Bottom up approaches:** Physical Vapor Deposition, Inert Gas Condensation, Laser Ablation, Chemical Vapor Deposition, Molecular Beam Epitaxy, Sol-gel method, Self-assembly, **Top down approaches:** Mechanical alloying, Nano-lithography. **Consolidation of Nanopowders**: Shock wave consolidation, Hot isostatic pressing and Cold isostatic pressing Spark plasma sintering.

**Unit IV: Tools to Characterize nanomaterials:** X-Ray Diffraction (XRD), Small Angle X-ray scattering (SAXS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM), Three-dimensional Atom Probe (3DAP), Nanoindentation.

**Unit V: Applications of Nanomaterials:** Nano-electronics, Micro- and Nano-electromechanical systems (MEMS/NEMS), Nanosensors, Nanocatalysts, Food and Agricultural Industry, Cosmetic and Consumer Goods, Structure and Engineering, Automotive Industry, Water-Treatment and the environment, Nano-medical applications, Textiles, Paints, Energy, Defence and Space Applications, Concerns and challenges of Nanotechnology.

**Text Books:**

Text Book of Nano Science and Nano Technology – B.S. Murthy, P. Shankar, Baldev Raj, B.B. Rath and James Munday, University Press-IIM.

Introduction to Nanotechnology – Charles P. Poole, Jr., and Frank J. Owens, Wley India Edition, 2012.

**References**

Nano: The Essentials by T.Pradeep, Mc Graw- Hill Education.

Nanomaterials, Nanotechnologies and Design by Michael F. Ashby, Paulo J. Ferreira and Daniel L.Schodek

Transport in Nano structures- David Ferry, Cambridge University press 2000

Nanofabrication towards biomedical application: Techniques, tools, Application and impact– Ed. Challa S.,S. R. Kumar, J. H. Carola.

Carbon Nanotubes: Properties and Applications- Michael J. O'Connell.

Electron Transport in Mesoscopic systems - S. Dutta, Cambridge University press.

**COURSE OUTCOMES:**

**The student will be able to**

1. Explain the concepts and applications of nanotechnology and the growth techniques of nanomaterials.
2. Apply the materials in the nanoscale.
3. Discuss about Synthesis Techniques of nanomaterials.
4. Classify the different characterization techniques of nanomaterials
5. Explain the applications in the fields of automobiles, textiles and energy.

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## BIOCHEMICAL ENGINEERING

**Prerequisite:** Chemical Reaction Engineering I&II, Chemical Process Calculations

**COURSE OBJECTIVES:**

1. To learn the basic concepts of cell function and biomolecules in analysis and design of industrial biochemical processes.

2. To understand the role of enzymes and development of mechanistic models for enzyme kinetics

3. Student will be able to Generate the growth kinetics of different organisms.&

3. To understand the various pathways by which cells consume and generate the energy for its function and growth.

4. To Design biological reactors.

5. To identify the basic separation and purification methods for products recovery and purification from bioreactors.

**UNIT 1**

Introduction to microbiology: Biophysics and the cell doctrine, the structure of the cells, important cell types, from nucleotides to RNA and DNA, amino acids into proteins. Kinetics of enzyme catalyzed reaction: the enzyme substrate complex and enzyme action. Simple enzyme kinetics with one and two substrates, other patterns of substrate concentration dependence, modulation and regulation of enzyme activity. Other influences on enzyme activity.

**UNIT 2**

Immobilized Enzyme Technology: Enzyme immobilization. Industrial Processes. Utilization and regeneration of Cofactor. Immobilized enzyme Kinetics. Effect of External Mass Transfer resistance. Analysis of intraparticle diffusion and reaction.

**UNIT 3**

Kinetics of cellular growth in batch and continuous culture. Models for cellular growth. Unstructured, structured and cybernetic models. Thermal death kinetics of cells and spores. Introduction to metabolic pathways, Biosynthesis, transport across cell membranes, end products of metabolism, Stoichiometry of cell growth and product formation.

**UNIT 4**

Design and analysis of biological reactors: Batch reactors, fed batch reactors, enzyme catalyzed reactions in CSTR, CSTR reactors with recycle and wall growth, Ideal plug Flow reactors,

Sterilization reactors, sterilization of gases, packed bed reactors using immobilized catalyst. Fermentation technology: Media formulation, design and operation of typical aseptic, aerobic fermentation process. Transport phenomena in bioprocess system: gas liquid mass transfer in cellular systems, determination of oxygen transfer rates, Overall $K_L$ a estimates and power requirements for sparged and agitated vessels, Scaling of mass Transfer equipments, Heat Transfer.

**UNIT 5:** Downstream Processing: Strategies to recover and purify products; Separation of insoluble product-Filtration and centrifugation; Cell Disrution-Mechanical and Non-Mechanical methods; Separation of Soluble products: Liquid-liquid Extractions, Membrane separation (Dialysis, Ultra filtration and reverse osmosis); Chromatographic separation-Gel permeation Chromatography, Electrophoresis, final steps in purification-Crystallization and drying.

**COURSE OUTCOMES:**

1. Student will understand the basic concepts of cell function and biomolecules in analysis and design of industrial biochemical processes.

2. Student will be able to understand the role of enzymes and development of mechanistic models for enzyme kinetics.

3. Student will be able to Generate the growth kinetics of different organisms.&
3. Understand the various pathways by which cells consume and generate the energy for its function and growth.

4. Student will able to Design biological reactors.

5. Student will able to identify the basic separation and purification methods for products recovery and purification from bioreactors.

**TEXT BOOKS:**

1. Biochemical Engineering Fundamentals, 2nd Ed, J.E. Bailey and D.F. Ollis, Mc Graw Hill Publishers, Newyork, 1987.
2. Bioprocess Engineering, 2nd Ed, M.L.Shuler and F.Kargi, PHI learning Pvt Ltd, New Delhi, 2009.

**REFERENCES:**

1. Biochemical Engineering, J.M.Lee, Prentice Hall, New Jersey, 1992.
2. Bioprocess Engineering principles, P.M.Doran, Elseveir Gurgaon, 2005.
3. Introduction to Biochemical Engineering,D.G.Rao,Tata McGraw Hill,New Delhi,2005.

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## FLUIDIZATION ENGINEERING

**PREREQUISITE:** Fluid Mechanics

**COURSE OBJECTIVES:**
The course will able the students to
1. Understand basic concepts of the fluidization phenomena,
2. Understand industrial applications of fluidized beds and their operational and design aspects.
3. Explain Fluidization and mapping of regimes
4. Understand Bubbling Fluidized beds
5. Understand Segregation and staging

**UNIT-I**
**Introduction**: The phenomenon of fluidization; liquid like behaviour of a fluidized bed; Comparison with other contacting methods; Advantages and disadvantages of fluidized beds.

**UNIT-II**
**Industrial applications of fluidized beds:** Coal gasification; gasoline from other petroleum fractions; Gasoline from natural and synthesis gases; Heat exchange; Coating of metal objects with plastics; Drying of solids; Synthesis of phthalic anhydride; Acrylonitrile; Polymerization of olefins; FCCU; Fluidized combustion of coal; incineration of solid waste; Activation of carbon; gasification of waste; bio-fluidization.

**UNIT-III**
**Fluidization and mapping of regimes:** Minimum fluidization velocity; Pressure drop vs. velocity diagram; effect of temperature and pressure on fluidization; Geldart classification of particles; terminal velocity of particles; turbulent fluidization; pneumatic transport of solids; fast fluidization; solid circulation systems; Voidage diagram; Mapping of regimes of fluidization.

**UNIT-IV**
**Bubbles in dense bed**: Single rising bubbles; Davidson model for gas flow at bubbles; Evaluation of models for gas flow at bubbles.
**Bubbling Fluidized beds**: Experimental findings; Estimation of bed porosities; Physical models: simple two phase model; K-L model.
**High velocity Fluidization**: Turbulent fluidized bed; Fast fluidization pressure drop in turbulent and fast fluidization.

**UNIT-V**

**Solids Movement, Mixing, Segregation and staging**: Vertical movement of solids; Horizontal movement of solids; Staging of fluidized beds.

**Gas Dispersion and Gas interchange in Bubbling Beds:** Dispersion of gas in beds; Gas interchange between bubble and emulsion; Estimation of gas interchange coefficients. Particle to Gas Mass Transfer**:** Experimental interpolation of mass transfer coefficients; Heat transfer; Experimental heat transfer from the bubbling bed model.

**COURSE OUTCOMES:**

1. The students will enable to apply fluidization concepts
2. The students will enable to design the fluidization bed reactors for chemical and allied industries.
3. The students will enable to apply concepts of bio-fluidization.
4. The students will enable to apply concepts of High velocity Fluidization
5. The students will enable to apply concepts of heat transfer from the bubbling bed model.

**TEXT BOOKS:**

1. Fluidization Engineering, 2nd ed., D. Kunii and O. Levenspiel, Butterworth-Heinemann, London, 1999.

**REFERENCES:**

1 Gas Fluidization Technology, D. Geldart Ed., John Wiley Sons, 1986.
2 Gas-Liquid-Solid Fluidization Engineering, Liang-Shih Fan, Butterworths, 1989
3 Fluidization Idealized and Bubbleless, with Applications, Mosoon Kwauk, Science Press, 1992

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## Membrane Technology

**PREREQUISITE:** Mass Transfer Operations and Chemical Reaction Engineering

**COURSE OBJECTIVES:**

1. To Understand the methods used for synthesizing the membranes
2. To Characterize & Select membrane for a given application
3. To Understand the mathematical models of membrane processes.
4. To analyse the membrane separation techniques
5. To analyse the membrane fouling reducing techniques

**UNIT I:**

Introduction: Separation process, Introduction to membrane processes, definition of a membrane, classifications membrane processes.

Preparation of Synthetic membranes: Types of Membrane materials, preparation of Synthetic membranes, phase inversion membranes, preparation technique for immersion precipitation, and preparation technique for composite membranes

**UNIT II:**

Characterization of membranes; Introduction, membrane characterization, characterization of porous membranes, characterization of non-porous membranes.

Transport in membranes: introduction, driving forces, non equilibrium thermodynamics, transport through porous, non-porous, and ion exchange membranes

**UNIT III:**

Membrane Processes: Introduction, osmosis, pressure driven membrane processes: Introduction, microfiltration, membranes for microfiltration, industrial applications, ultra filtration: membranes for ultra filtration, industrial applications, reverse Osmosis and nanofiltration: membranes for reverse osmosis and nanofiltration, industrial applications, Electrically Driven processes: Introduction, electrodialysis, Process parameters, membranes for electrodialysis, applications, Membrane electrolysis, Bipolar membranes, Fuel Cells.

**UNIT IV:**

Concentration driven membrane processes: gas separation: gas separation in porous and non porous membranes, membranes for gas separation, applications, pervaporation, membranes for pervaporation, applications, dialysis: membranes for dialysis, applications, liquid membranes: aspects, liquid membrane development, choice of the organic solvent and carrier, applications, introduction to membrane reactors.

**UNIT V:**
Polarization phenomenon and fouling: Introduction to concentration polarization, turbulence promoters, pressure drop, gel layer model, osmotic pressure model, boundary layer resistance model, concentration polarization in diffusive membrane separations and electro dialysis, membrane fouling, methods to reduce fouling, compaction. Module and process design: Introduction, plate and frame module, spiral wound module, tubular module, capillary module, hollow fiber module, comparison of module configurations.

**Course Outcomes:**

At the end of the course the student will be able to:

1.Understand the methods used for synthesizing the membranes
2. Characterize & Select membrane for a given application
3. Understand the mathematical models of membrane processes.
4. Analyse the membrane separation techniques
5. Analyse the membrane fouling reducing techniques

TEXT BOOKS:

1. Membrane Separations, M.H.V. Mulder, Springer Publications, 2007
2.Rate-Controlled Separations, P. C. Wanket, Elsevier Applied Science, London,1994.

REFERENCE BOOKS:

1.Membrane Technology in the Chemical Industry, S.P. Nunes, K.V. Peinemann, Wiley-
2. Membrane Processes in Separation and Purification, J.G.Crespo, K.W.Bodekes, Kluwer Academic Publications
3. Membrane Separation Processes, K. Nath, PHI Pvt. Ltd., New Delhi,2012.

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## OPTIMIZATION OF CHEMICAL PROCESSES

**Prerequisite:** Mathematics-I, II, II, and Chemical Process Calculations

**COURSE OBJECTIVES:**

1. To provide students understanding of different Optimization techniques.Like linear programming and genetic algorithms.
2. Understand different search techniques and apply in process design.
3. To give emperor to application of optimization techniques in petro chemical process.
4. To apply the optimization technique in distillation column design.
5. To apply the Principles of optimization in Bio- Chemical engineering.

**Unit-I:**

**Nature and organization of optimization problems:** what optimization is all about, why optimize, scope and hierarchy of optimization, examples and applications of optimization, the essential features of optimization problems, general procedure for solving optimization problems, obstacles of optimization, classification of models, how to build a model, fitting functions to empirical data, the method of least squares, factorial experimental design, fitting a model to data subject to constraints.

**Unit-II:**

**Basic concepts of optimization:** Continuity of functions, unimodal versus multimodal functions, convex and concave functions, convex region, necessary and sufficient conditions for an extremum of an unconstrained function, interpretation of the objective function in terms of its quadratic approximation.

**Optimization of unconstrained functions:** one-dimensional search: Numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of uni-dimensional search, region elimination methods, polynomial approximation methods, how the one-dimensional search is applied in multi-dimensional problem, evaluation of uni-dimensional search methods.

**Unit-III:**

**Unconstrained multivariable optimization:** direct methods, random search, grid search, univariate search, simplex method, conjugate search directions, Powell's method, indirect methods-first order, gradient method, conjugate method ,indirect method-second order-Newton's method forcing the Hessian matrix to be positive definite, Movement in the search directions, termination, summary of Newton's method, relation between conjugate gradient and Quasi-Newton method.

**Unit-IV:**

**Linear programming and applications:** Basic concepts in linear programming, Degenerate LP's-graphical solution, natural occurrence of linear constraints, the simplex method of solving linear programming problems, standard LP form, obtaining a first feasible solution, the revised simplex method, sensitivity analysis, duality in linear programming, the Karmarkar algorithm, LP applications.

**Genetic Algorithms:** (Qualitative treatment) Working principles, differences between GAs and traditional methods, similarities between GAs and traditional methods, GAs for constrained optimization, other GA operators, real coded GAs, Advanced GAs.

**Unit-V:**

**Optimization of unit operations-1:** recovery of waste heat, shell and tube heat exchanger, evaporator design, liquid-liquid extraction process, optimal design of staged distillation column.

**Optimization of unit operations-2:** Optimal pipe diameter, optimal residence time for maximum yield in an isothermal batch reactor, chemo stat, optimization of thermal cracker using linear programming.

**COURSE OUTCOMES:**

1. Student will able to formulate unconstrained or constrained objective functions of chemical engineering problems.
2. Gains exposure to application of optimization techniques in case of various petrochemical processes
3. Understands how the problem formulation influences its solvability and interpretation of optimization results.
4. Student will able to formulate Linear programming and applications
5. Student will able to Understand Genetic Algorithms

**TEXT BOOKS:**

1. Optimization of chemical processes by T.F.Edgar and Himmelblau D.M. Mc- Graw. Hill. New York, 2001.
2. Optimization for Engineering Design, Kalyan Moy Deb, PHI Pvt Ltd, New Delhi, 2000.

**REFERENCES:**

1. Elementary Principles of Chemical Processes, 4th Edition, Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard

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## FERTILIZER TECHNOLOGY

**COURSE OBJECTIVES:**

The objective of this course is

1. To understand basic concepts and manufacturing processes of synthetic fertilizers.
2. To under the use of fertilizers to improve soil productivity and crop yield
3. To learn different types of the nitrogenous, phosphatic and potash fertilizers and different organic fertilizer production methods.
4. To study the Formulate and compound fertilizers and Produce fertilizers at the desired rates.
5. To understand basic concepts and manufacturing processes of bio-fertilizers, organic manures.

**UNIT-I**

Overview: Development of fertilizer industry; Fertilizers production and consumption in India; Nutrient contents of fertilizers; Secondary nutrients; Feedstock and raw materials for nitrogenous, phosphatic and potassic fertilizers. Organic manures.

**UNIT-II**

Nitrogenous fertilizers: Ammonia from natural gas, associated gas, coke oven gas, naphtha, fuel oils; ammonium nitrate, calcium ammonium nitrate, ammonium chloride – their methods of production, characteristics and storage and handling specifications.

**UNIT-III**

Phosphatic fertilizers: single super phosphate, triple superphosphate potassic fertilizers: Potassium chloride, potassium sulphate.

Complex fertilizers: Ammonium phosphate, ammonium sulphate, MAP/ DAP, nitro phosphates, urea-ammonium phosphates - their methods of production, characteristics and storage and handling specifications.

**UNIT-IV**

Miscellaneous fertilizers: Organic Manures, Biofertilizers: N2 Fixing Biofertilizers, P solubilizing-biofertilizers, P-mobilizing-biofertilizers; liquid fertilizers, controlled release fertilizer. Design aspects of ammonia synthesis converters, urea autoclave, pipe reactors, prilling tower.

**UNIT-V**

Retrofitting, upgrading and modernization of existing plants. General fertilizer storage and handling; Corrosion problems in fertilizer industries; Fertilizer plants effluent treatment and disposal. Case study of selected fertilizer plants with environmental aspects.

**COURSE OUTCOMES:**

The students will be able to

1. Apply fertilizer concept to manufacture fertilizers and design the fertilizer industries equipment
2. Prepare synthesis path for manufacturing synthesis gas Differentiate various Ammonia converter.
3. Characterize fertilizers on the basis of different properties.
4. Identify engineering problems in fertilizer manufacturing. iv. Handle the fertilizers. v. Select appropriate synthesis fertilizer
5. Use reactions and unit operations steps in manufacturing of various fertilizers.

**TEXT BOKS:**

1. "Handbook of Fertilizer Technology", Fertilizer Association of India, New Delhi
2. "Production of Fertilizers (Booklets 1 to 8)", European Fertilizer Manufacturers' Association.

**REFERENCES:**

1. Dryden's Outlines of Chemical Technology, M. Gopala Rao Sitting Marshall, Affiliated East West Press (Pvt) Ltd, 3 rd Ed., New Delhi.
2. Shreve's Chemical Process Industries, 5th edition, Austin G.T. McGraw Hill publication, New Delhi.
3. Chemical Technology -Vol. I and II, 2nd edition Pandey G.N. and Shukla Vani Books Company - Hyderabad

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**ENTREPRENEURSHIP DEVELOPMENT**

**COURSE OBJECTIVES:**

1. To provide insights into basic characteristics and process of entrepreneurship
2. To develop a business idea and prepare a bankable project report
3. To identify the methods to initiate ventures and the sources of finance
4. To create awareness about the legal challenges of entrepreneurship and IPR
5. To know and apply the various strategic and managerial concerns in the growth stage of the firms

**UNIT- I**

**Introduction:**

Introduction to Entrepreneurship – Characteristics, Qualities, Key Elements and Skills of an Entrepreneur, entrepreneurial stress, Corporate entrepreneurship, Entrepreneurial process.

**UNIT –II**

**Business Plan Preparation:**

Search for business idea, project identification, project formulation and development, contents of business plan and Preparation of a Bankable Project Report.

**UNIT-III**

**Launching Entrepreneurial Venture:**

Opportunities identification, Methods to initiate Ventures, Creating new ventures, Acquiring existing ventures, Franchising. Sources of finance, Forms of capital requirements, funding agencies and supporting institutions.

**UNIT IV:**

**Legal challenges of Entrepreneurship:**

Intellectual Property Protection – Patents, Copyrights, Trademarks and Trade Secrets. The challenges of new Venture Startups- Poor financial understanding, critical factors for new venture development, Evaluation process, Feasibility criteria approach.

**UNIT V:**

**Strategic perspectives in Entrepreneurship**:

Strategic planning- Strategic Action, Strategic Positioning, Business Stabilization, Building the adaptive firms, understanding the growth stage, unique managerial concern of growing ventures.

**COURSE OUTCOMES:**

At the end of the course, students will be able to

1. Interpret concepts and process of entrepreneurship.
2. Apply idea development strategies and prepare a bankable project report
3. Analyse various opportunities towards initiating ventures.
4. Recognize legal challenges of entrepreneurship.
5. Assess the strategic perspectives of entrepreneurship.

**Text Book:**

**1.** D F Kuratko and T V Rao "Entrepreneurship- A South-Asian Perspective "Cengage Learning, 2012
**2.** Vasant Desai, Small Scale Industries and Entrepreneurship, HPH, 2012.

**References:**

1. Rajeev Roy, Entrepreneurship, 2e, Oxford, 2012.
2. B.Janakiram and M.Rizwana, Entrepreneurship Development:Text & Cases, Excel Books, 2011.
3. Stuart Read, Effectual Entrepreneurship, Routledge, 2013.
4. Robert Hisrich et al, Entrepreneurship, 6e, TMH, 2012.
5. Nandan H, Fundamentals of Entrepreneurship, PHI, 2013
6. Shejwalkar, Entrepreneurship Development, Everest, 2011
7. Khanka, Entrepreneurship Development, S.Chand, 2012

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## CHEMICAL REACTION ENGINEERING LAB

**COURSE OBJECTIVES**

1. Determine the reaction order and specific reaction rate from experimental data.
2. Develop rate laws for use in reactor design based on reaction data from a reactor or set of reactors.
3. To impart knowledge on different types of chemical reactors.
4. Design of chemical reactors under isothermal and non-isothermal conditions.
5. To enable the students to learn the gas-solid catalytic and non-catalytic reactors and gas-liquid reactors.

(Atleast **Ten** experiments out of the following experiments should be performed)

1. Determination of the kinetic parameters (reaction rate constant and order) and analyzing the data by Differential method of analysis and Integral method of analysis.
   Major Equipment – Batch Reactor Setup
2. Determination of the rate constant and to find the temperature dependence using Arrhenius form of equation.
   Major Equipment – Batch Reactor Setup
3. Determination of the kinetic parameters (order, reaction rate constant) of given reactor system
   Major Equipment – CSTR Apparatus
4. Determination of the kinetic parameters (order, reaction rate constant) of given reactor system
   Major Equipment – PFR Apparatus
5. Determine the RTD and axial dispersion number in a tubular column using a tracer.
   Major Equipment – Tubular Reactor Apparatus
6. Determine RTD and dispersion number (axial dispersion number) for a packed bed using a tracer.

Major Equipment – Packed Bed Reactor Apparatus

7. Determine the mass transfer coefficient with and without chemical reaction for a solid –liquid system

   Major Equipment: solid – liquid system setup

8. Determine the mass transfer coefficient with and without chemical reaction for a liquid –liquid system

   Major Equipment: liquid – liquid system setup

9. Compare the performance of mixed flow reactor in series with that of an ideal reactor.

   Major Equipment – CSTRs in series Apparatus

10. Determine RTD and dispersion number (axial dispersion number) for a given mixed flow reactors in series using a tracer.

    Major Equipment – CSTRs in series Apparatus

11. Determine the conversion of reactants with semi batch reaction

    Major Equipment – Semi Batch Reactor setup

**COURSE OUTCOMES:**

**Students will be able to**

1. Apply experimentally the kinetics and rate constants of reactions in different types of reactors. These studies have wide applications in various process industries.
2. Evaluate the selection of the reactor for the reaction and its design.
3. Comparisons of ideal reactor and real reactors types (batch, plug flow, mixed flow Reactors etc)
4. Optimize the best choice for simple objectives when using a single reactor or a set of reactors in RTD studies.
5. Solve both open-ended and closed-ended reaction engineering problems.

**TEXT BOOK:**

1. Chemical Reaction Engineering, 3rd Edition. O. Levenspiel, John Wiley and Sons, 1999.

**REFERENCES:**

1. Elements of Chemical reaction engineering by H.S. Fogler, 2nd ed.PHI, 1992.

2. Chemical engineering Kinetics by J.M. Smith, 3rd ed. Mc Graw Hill, 1981.

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## MASS TRANSFER OPERATION LAB

**COURSE OBJECTIVES:**

1. To provide students complete understanding of mass transfer operations and apply in professional life there by communicating effectively.
2. Evaluation of Mass transfer coefficients for Wetted wall column
3. To analyze time of Batch Drying
4. To develop Vapor Liquid Equilibria and Liquid- liquid Equilibria.
5. Evaluation of HETP in packed towers.

**List of experiments**

1. Estimation of diffusivity coefficients.
   Major equipment-Diffusivity apparatus

2. Determination of Steam distillation Temperature
   Major equipment-Steam distillation unit

3. Verification of Rayleigh's Equation by differential distillation.
   Major equipment- Differential Distillation unit

4. Packed towers,HETP evaluation.
   Major equipment-Packed column unit

5. Vapor-Liquid Equilibria.
   Major equipment-VLE apparatus

6. Batch Drying.
   Major equipment-Tray dryer

7. Evaluation of mass transfer coefficients for Wetted wall column.
   Major equipment-Wetted wall column unit

8. (a)Liquid-Liquid Equilibria(Tie line data) (b)Ternary Liquid Equilibia (binodal curve).
   Major equipment-LLE setup

9. Solid Liquid Equilibria: Calcium carbonate and Water

10. Solubility characteristics.

**COURSE OUTCOMES:**

1. The student will be able to perform VLE, LLE related experiments and can estimate diffusivity coefficients.
2. The student will be able to learn about the calculation of different parameters in distillation, absorption, drying and extraction operations.
3. The student will be able to design distillation units, drying and evaporation units.
4. The student able to calculate the HETP for packed towers
5. To solve industry related problems including design and to respond to changing impact of chemical engineering solutions at a global level and in society

**TEXT BOOKS:**

1. Mass transfer operations by R.E. Treybal, 3rd ed. Mc Graw Hill, 1980.
2. Unit Operations in Chemical Engineering, McCabe, W.L., Smith, J.C., and Harriot, P., McGraw-Hill VII Edn., 2004.

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## RENEWABLE ENERGY TECHNOLOGY

**Prerequisite**: Energy Engineering, Water conservation and management, Nuclear Engineering.

**COURSE OBJECTIVES:**

1. To explain the concepts of Non-renewable and renewable energy systems
2. To outline utilization of renewable energy sources for both domestic and industrial applications
3. To analyze the environmental and cost economics of renewable energy sources in comparison with fossil fuels.
4. To illustrate the characteristics and applications of Wind energy.
5. To study the various other renewable sources of energy.

**UNIT I:**

Introduction to renewable energy, world energy status, current energy scenario in India, environmental aspects of energy utilization, energy and sustainable development, Overview of conventional & renewable energy sources, need & development of renewable energy sources.

**UNIT II: Solar Energy:**

Solar energy (basic concepts, flat plate and concentrating collectors, solar desalination, solar pumping, solar photo voltaic conversion, solar cells), applications of solar energy systems.

**UNIT III: Wind Energy:**

Wind energy (availability, wind power plants, wind energy conversion systems, site characteristics, types of wind turbines), classification of wind, characteristics, applications of wind turbines, offshore wind energy – Hybrid systems, wind resource assessment, Betz limit, site selection, wind energy conversion devices

**UNIT IV: Energy from biomass:**

Energy from biomass(biomass resources, biomass conversion technologies - direction combustion, pyrolysis , gasification, anaerobic digestion, bioethanol and biodiesel production) analysis, Properties of biogas (Calorific value and composition), biogas plant technology and status, Bio energy system, design and constructional features.

**UNIT V:**

Other Renewable Sources (Tidal energy; geothermal energy; hydroelectric), Tidal and wave energy its scope and development, Scheme of development of tidal energy. Small hydro Power Plant: Importance of small hydro power plants and their Elements, types of turbines for small hydro, estimation of primary and secondary power. Geothermal Energy: Geothermal power plants, various types, hot springs and steam ejection.

**COURSE OUTCOMES: Students will able to**

1. Understand the various renewable energy sources available and also the current scenario of energy in India.
2. Understand one of the most important types of renewable energy -solar energy.
3. Understand the various types of other renewable energy resources for producing energy.
4. Analyze and quantify energy usage using energy from biomass.
5. Understand the wind energy conservation and systems and types of wind turbines.

**TEXT BOOKS:**

1.Fundamentals of Renewable energy systems, D. Mukherjee, S. Chakrabarti, New Age International Publishers.

2. Textbook of Renewable Energy, S.C. Bhatia, R.K. Gupta, Woodhead Publishing India Pvt. Ltd.

**REFERENCES:**

1. Renewable Energy Technology, I S Jha, Subir Sen, M K Tiwari, D P Kothari, New Age International Publishers.

2. Renewable Energy Sources and Management, Ganesh S. Mali, Prakash Patil, Nirali Prakashan.

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# (AUTONOMOUS)

| IV B.Tech. – I Sem | L | T/P/D | C |
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## INTELLECTUAL PROPERTY RIGHTS

**Course Objectives:** After completing this course the student will be able

1. To understand the concepts of Intellectual Property Rights and related agencies.
2. To know about the purpose and functions of Trademarks in competitive environment
3. To explain the process of Patent and Copyrights and related procedures
4. To know the Trade Secret Law and its protection from Unfair practices.
5. To get knowledge on the overview of International Intellectual Property Scenario.

**Unit I:**

**Introduction to Intellectual Property:** Introduction, Types of Intellectual Property, International Organization, Agencies and Treaties, Importance of Intellectual Property Rights.

**Unit II:**

**Trademarks:** Purpose and Function of Trademarks, Acquisition of Trademarks Rights, Protectable Matter, Selecting and Evaluating Trade Mark, Trade Mark Registration Processes.

**Unit III:**

**Law Of Copy Rights & Patents:** Fundamental of Copy Rights Law, Originality of Material, Rights of Reproduction, Rights to Perform the Work Publicly, Copy Right Ownership Issues, Copy Right Registration, Notice of Copy Right, International Copy Right law. Foundation of Patent Law, Patent Searching Process, Ownership Rights & Transfer.

**Unit IV :**

**Trade Secrets & Unfair Competition:** Trade Secret Law, Determination of Trade Secret Status, Liability for Misappropriation Right of Trade Secrets, Protection for Submission, Trade Secret Litigation. Misappropriation Right of Publicity, False Advertising.

**Unit V:**

**New Development & International Overview On Intellectual Property:** New Developments in Trade Mark Law, Copy Right Law, Patent Law, and Intellectual Property Audits. International Trade Mark Law, Copy Right Law, International Patent Law, International Development in Trade Secrets Law.

**Course Outcomes:** After completing this course the student will be able to

1. Explain the concepts of Intellectual Property Rights and related agencies.
2. Describe the purpose and functions of Trademarks in Competitive Environment
3. Analyze the process of Patent and Copyrights and related procedures
4. Explore the Trade secret law and its protection from Unfair practices
5. Explain the overview of International Intellectual Property Scenario

**TEXT BOOKS:**

1. Deborah. E. Bouchoux, Intellectual Property Rights, Cengage learning

2. Prabuddha Gangulli, Intellectual Property Rights Unleashing the knowledge economy, Tata Mc Graw Hill Publishing Company Ltd.

**REFERENCES:**

1. Khushdeep Dharni and Neeraj Pandey, Intellectual Property Rights, PHI Learning Pvt. Ltd.
2. Vivien Irish, Intellectual Property Rights for Engineers, 2nd edn, IET, 2005
3. Carlos Alberto Primo Braga, Carsten Fink, Claudia Paz Sepulveda, Intellectual Property Rights and Economic Development, World Bank Publications, 2000

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# (AUTONOMOUS)

**IV B.Tech. – I Sem**

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## DISASTER PREPAREDNESS & PLANNING MANAGEMENT

**COURSE OBJECTIVES:**

As student work through this session he/she will learn to

1. To know the concept, definition and terminology of the Disaster Management.
2. To know the classification & occurrence of disasters in India and elsewhere.
3. To know and analyse the socio-economic, environmental & political and gender etc., aspects of disasters impacts.
4. To know the Pre, Post and emergency management mitigation strategies &activities of Disaster Management Cycle.
5. To know the environment of vulnerable Disaster areas & to implement developmental activities to minimise the impacts.

UNIT – I: INTRODUCTION

Concepts and definitions: disaster, hazard, vulnerability, risk, capacity, impact, prevention, mitigation.

UNIT – II: DISASTERS

Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills etc); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility.

UNIT – III: DISASTER IMPACTS

Disaster impacts (environmental, physical, social, ecological, economical, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate-change and urban disasters.

UNIT – IV: DISASTER RISK REDUCTION (DRR)

Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

UNIT – V: DISASTERS, ENVIRONMENT AND DEVELOPMENT

Factors affecting vulnerability such as impact of developmental projects and environmental modifications (including of dams, land-use changes, urbanization etc.), sustainable and environmental friendly recovery; reconstruction and development methods.

**COURSE OUTCOMES:**

The student will be able

1. To acquire knowledge of concepts and terminology to understand disaster Management.
2. To acquaint with different disasters in India and other parts of the world.
3. To classify, assess the magnitude & intensity of various impacts of disasters.
4. To learn the management methods (Risk & crisis Mgmt) at various stages of Disaster.
5. To learn effective sustainable environmental modification techniques to decrease the vulnerability in disaster prone areas.

**TEXT BOOKS:**

1. Disaster Management - *H.K. Gupta* - University Press, India, 2003.
2. Handbook of Disaster Management: techniques & Guidelines - *Singh B.K., Rajat* Publications, 2008.
3. Disaster Mitigation: Experiences and Reflections - *Pardeep Sahni*
4. Disaster Risk Reduction in South Asia - *Pradeep Sahni* - Prentice Hall, 2004.

**REFERENCE BOOKS:**

1. Disaster Management - *Ghosh G.K*., APH Publishing Corporation, 2006.
2. Disaster Management - *R.R Singh* - Rawat Publication, New Delhi, 2000.
3. Space Technology for Disaster Mitigation in India (INCED) - *R.R. Singh*,University of Tokyo, 1994.
4. Disaster Management in Hills- *Dr. Satender* - Concept publishing co.,New Delhi, 2003.
5. Action plan For Earthquake, Disaster, Mitigation in Disaster Management - *A.S. Arya , V.K. Sharma* , IIPA publications, New Delhi, 1994.
6. An overview on Natural & Man-made Disaster & their Reduction - *R.K.Bhandani*, CSIR, New Delhi.
7. Manuals on Natural Disaster management in India - *M.C. Gupta*, National Centre for Disaster Management, IIPA, New Delhi, 2001

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# (AUTONOMOUS)

**IV B.Tech. – I Sem**

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## PROCESS INSTRUMENTATION AND CONTROL

**PREREQUISITE:** Mathematics-I, II, III and Process Instrumentation, Chemical Engineering Fluid Mechanics, Mass transfer Operations.

**COURSE OBJECTIVES**

1. To represent dynamic systems by equations and by transfer functions in block diagrams and to obtain transient response to disturbances like step, impulse, ramp and sinusoidal forcing function.
2. To estimate the stability limits for a system, with or without control.
3. To calculate and use the frequency response of a system
4. To analyze, design and tune feedback / feed forward, cascade and model based controllers in the context of various control strategies used to control chemical processes.
5. To have firm knowledge on different measuring devices.

**UNIT I:** Introduction to process Dynamics and control. Mathematical tools for modeling. Solutions of Ordinary Differential equations using Laplace transform. Inversion by partial fractions. Further properties of Transforms and Partial Fractions. Response of I order systems: Transfer Function, Transient response to step, impulse, ramp and sinusoidal forcing function. physical examples of first order systems: liquid level, mixing process, heating process. Concept of time constant. Linearization. Response of first order systems in series: interacting and non-interacting systems.

**UNIT II:** Higher order systems: Second order system- Transient response of under damped, critically damped, over damped systems to step, impulse and sinusoidal forcing functions. Transportation lag. The Control System: Components of a control system, Negative and Positive feedback control systems, Servo and Regulatory control problems, Development of Block diagram, Controllers and final control elements. Reduction of physical control systems to block diagrams: Block diagram of a chemical reactor control system. Closed loop Transfer function. Overall Transfer functions for single loop control systems. Overall Transfer functions for multi loop control systems. Transient response of simple control systems.

**UNIT III:** Stability: Concept of stability. Stability criterion. Routh Test for stability. Root Locus: concept of root locus, plotting of the root locus diagram for feedback control systems. Transient response from root locus. Application of root locus to control systems. Introduction to frequency response: Bode diagrams for first order, first order system in series, second order systems and for controllers and transportation lag. Bode stability criterion. Gain margin and phase margin. Control system design by frequency response. Nyquist Plots. Nyquist stability criteria.

**UNIT IV:** Advanced control strategies: Cascade Control. Feed Forward Control. Ratio control. Smith Predictor. Controller tuning: ISE, ITAE, IAE, Ziegler – Nicholas and Cohen-Coon tuning methods. Measuring devices: The elements of Instruments, Static and dynamic characteristics.

**UNIT V:** Temperature measuring instruments: Mercury-in-Glass thermometer, Bimetallic thermometer and industrial resistance thermometer; Liquid-level measuring instruments: Float-and-Tape Liquid-level gauge, Float-and-shaft Liquid-level gauge and Bubbler system for Liquid-level measurement; Pressure measuring instruments: Pirani vacuum gauge and McLeod pressure gauge; Measurements of viscosity: Viscosity Meter and continuous viscosity meter; Gas analysis by thermal conductivity; Composition analysis: Absorption spectroscopy and mass spectroscopy ;Instrumentation diagram.

**COURSE OUTCOMES:**

A student will be able to:

1. Understand the dynamic behavior of different processes.
2. Analyze different components of a control loop
3. Analyze stability of feedback control system.
4. Able to understand the various advanced control strategies.
5. Have firm knowledge on the measurement of processes variables instruments.

**TEXT BOOKS:**

1. Process System Analysis and Control, 3rd Ed., D.R. Coughanowr and Steven E. Le Blanc, Mc Graw Hill, 2009.
2. Donald P. Eckman, "Industrial Instrumentation", Wiley Eastern Limited, 2004

**REFERENCES:**

1. Chemical Process Control, G. Stephanopoulos, PHI learning Pvt Ltd., New Delhi, 2010.
2. Outlines of Chemical Instrumentation and Process Control, 3rd Ed., A. Suryanarayana, Khanna Publishers, New Delhi, 2010.

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| **IV B.Tech. – I Sem** | **L** | **T/P/D** | **C** |
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## PROCESS MODELING AND SIMULATION

**Prerequisite:** Fluid Mechanics, Mass Transfer, Heat Transfer, Chemical Process Calculations

**COURSE OBJECTIVES**

1. To give the basics of theoretical modeling by the application of Fundamental laws.
2. To get introduced to modeling and simulation of steady state and dynamic behavior.
3. To train students in computer programming abilities for solving iterative problems.
4. To apply mass and energy balances for Chemical Engineering systems.
5. To solve basic Chemical engineering problems in mass, heat and momentum transfer.

**UNIT-I**

Mathematical models for chemical engineering systems, fundamentals, introduction to fundamental laws.

Examples of mathematical models of chemical engineering systems, constant volume CSTRS, two heated tanks, and gas phase pressurized CSTR, non-isothermal CSTR.

**UNIT –II**

Examples of single component vaporizer, batch reactor, reactor with mass transfer, ideal binary distillation column, batch distillation with holdup

**UNIT -III**

Computer simulation, examples, gravity flow tank, three CSTRs in series, binary distillation column, batch reactor.

Simulation of Non-isothermal CSTR, VLE dew point, bubble point calculations, counter current heat exchanger

**UNIT -IV**

Mathematical formulation of the Physical Problems:

Application of the law of conservation of mass-Salt accumulation in a stirred tank- starting an equilibrium still-solvent extraction in two stages-Diffusion with chemical reaction.

Application of the law of conservation of energy-Radial heat transfer through a cylindrical conductor-Heating a closed Kettle.

**UNIT -V**

The difference operator-Properties of the difference operator-Difference tables and other difference operators. Linear Finite Difference Equations: Simultaneous linear differential equations-Calculation of Number of theoretical stages in Liquid Liquid Extraction column. Nonlinear Finite Difference Equations: Graphical Solution-Analytical solution--Calculation of the number of CSTR reactors for Specific Conversion--Calculation of the number of theoretical plates required for distillation column.

**COURSE OUTCOMES:**

**Students will be able to:**

1. Derive mass balance, energy balance and momentum balance equations for various chemical process systems.
2. Develop models for various systems such as reactors, distillation columns, heat exchangers and analyze their behavior.
3. Apply numerical methods to simulate various processes of chemical industries.
4. Solve various types of equations including linear, non-linear, ordinary and partial differential equations.
5. Develop finite difference equations for chemical engineering systems.

**TEXT BOOKS:**

1. Process Modeling Simulation and Control for Chemical Engineers by W. L. Luyben, McGraw Hill, 2nd Ed., 1990.
2. "Mathematical Methods in Chemical Engineering" by Jenson, V.J. and G.V.Jeffereys, Academic Press. London and New York, 2nd Ed., 1977

**REFERENCE:**

1. Modeling and analysis of Chemical Engineering processes by K.Balu and K. Padmanabhan, IK International private limited, 2007

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| IV B.Tech. – I Sem | L | T/P/D | C |
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## CHEMICAL PROCESS EQUIPMENT DESIGN

**Prerequisite:** Heat Transfer, Fluid Mechanics, Mass Transfer, Chemical Process Calculations

**Course Objective:**
The objective of this course is

1. To acquire basic understanding of various design parameters and to design various Chemical Engineering equipments.
2. Study relevant codes for design of chemical plant equipment as per the standard procedures specified by design code books.
3. Learn the fabrication techniques and testing methods.
4. Study design safe process and design appropriate equipment like reactors, mass transfer heat transfer equipment, pipelines storage tanks etc.
5. Learn design and engineering skills directly applied in design, installation and commissioning of equipments.

**UNIT I:**
**Introduction to Equipment Design**
Introduction; development of flow and block diagrams from process description, Piping and instrumentation diagram ,material and energy balance, sizing of equipment, design preliminaries, design codes, Material of construction selection procedure, fabrication methods and testing methods, selection of equipments for gas, liquid and solid processes.

**UNIT II:**
**Mechanical design of process equipment**
Fundamentals principles and equations, General Design considerations of pressure vessels, Design of thin walled vessels under internal and external pressure, compensation for opening and braches, Design vessels subjected to combined loading, theories of failure, design of flange joints and supports, design of high pressure vessels, design of storage vessels for volatile and non volatile liquids.

**UNIT III:**
**Design of shell and tube heat exchangers**
Basic procedure and theory ,Overall heat transfer coefficient, fouling factors, Shell and tube exchanger construction details, mean temperature difference, General design considerations of

shell and tube exchanger, tube side heat transfer coefficient and pressure drop ,shell side heat transfer and pressure drop.

**UNIT IV:**

**Design of separation columns (Distillation, Absorption & extraction)**

Continuous distillation basic principles and process description, Design variables in distillation column, Design methods for binary systems, plate efficiency, plate contractors, plate hydraulic design, packed columns.

**UNIT V:**

**Design of reactor, evaporator**

Introduction, material of construction, Agitation, classification of reactor vessels, reactor selection, Design considerations, Types of evaporators, Design considerations of evaporator, Optimum pipe diameter.

**COURSE OUTCOMES:**

The student will be

1. Select important parameters of equipment design ,Mechanical properties of materials to be used as MOC.
2. Ability to design internal pressure vessels and external pressure vessels ,special vessels (e.g. tall vessels) and various parts of vessels (e.g. heads) including various unit operation equipments.
3. Ability to Design heat transfer equipments and cooling and heating systems.
4. Ability to scale-up mass transfer processes.
5. Ability to scale-up homogeneous and heterogeneous reactors.

**TEXT BOOKS:**

1. Chemical Engineering Design: Vol.6, Coulson J.M. and Richardson J.F., Pergamon Press 1983.
2. Process Equipment Design, M.V. Joshi and V. V. Mahajani, 3rd Ed, Mac Millan India Ltd, 1996.

**REFERENCES:**

1. Process Design of Equipments, Dr. Shrikanth D. Dawande, Central Techno Publications, 2nd Ed, 2000.
2. Process Equipment Design-Vessel Design: Brownell L.E., Wiley Eastern Ltd.,1986.
3. Introduction to Chemical Equipment Design-Mechanical Aspects: Bhattacharya B.C., CBS Publishers, 1991.
4. Process Heat Transfer: Kern Q., McGraw Hill book Co. Inc., 1982.
5. Mass Transfer Operations: Treybal R.E., MGH Book Co.Inc, 3rd Ed., 1982.
6. Chemical Engineering Hand Book, Perry, 8th Ed., Mc GrawHill, New York, 2008.

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| IV B.Tech. – I Sem | L | T/P/D | C |
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## TRANSPORT PHENOMENA

**Prerequisite**: Fluid mechanics, Mass Transfer, Heat Transfer

**COURSE OBJECTIVES: Students will able**

1. To provide fundamentals of momentum, heat and mass transfer and to study analogy between momentum, heat and mass transfer.
2. The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction, forced and free convection, binary diffusion with or without chemical reaction
3. To evaluate the concept of diffusivity and mechanism of mass transport.
4. To illustrate the equations of change for isothermal systems.
5. To study and understand the concept of velocity distribution in laminar flow.

**UNIT I:**

**Viscosity and the mechanisms of momentum transfer:** Importance of transport phenomena, analogous nature of transfer process, Introduction of viscosity and mechanism of momentum transport: Newton's law of viscosity, Newtonian & Non-Newtonian fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases and liquids.

**Velocity distribution in laminar flow**: Shell momentum balances and boundary conditions of -

a) Flow of falling film b) Flow through the circular tube c) Flow through an annulus d) Adjacent flow of two immiscible fluids.

**UNIT II:**

**Thermal Conductivity and mechanism of energy transport :** Introduction to thermal conductivity and mechanism of energy transport: Fourier's law of heat conduction, temperature and pressure dependence of thermal conductivity and theory of thermal conductivity of gases at low density.

**Temperature distribution in solids and in laminar flow & numerical problems** -

a) Shell energy balance, boundary conditions b) Heat conduction with electrical heat source c) Heat conduction with a nuclear heat source d) Heat conduction with a viscous heat source e)

Heat conduction with a chemical heat source f) Heat conduction through composite walls g) Forced and free convection h) Heat conduction in a cooling fin.

**UNIT III:**

**Diffusivity and mechanisms of mass transport**: Introduction to diffusivity and mechanism of mass transport: Definitions of concentrations, velocities and mass fluxes, Fick's law of diffusion, temperature and pressure dependence of mass diffusivity.

**Concentration distribution in solids and in laminar flow & numerical problems** -

a) Shell mass balances, boundary conditions b) Diffusion through stagnant gas film c) Diffusion with heterogeneous chemical reaction d) Diffusion with homogeneous chemical reaction e) Diffusion into falling liquid film etc.

**UNIT IV:**

**Unsteady Momentum Transport:**

**Equations of change for isothermal system -** a) The equation of continuity b) The equation of motion c) Equation of change in curvilinear coordinate systems d) Use of equation of change to set up steady flow problem e) Equation of mechanical energy f) Dimensional analysis of equation of change.

**UNIT V:**

**Simultaneous & Analogy momentum, heat and mass transfer:**

**Momentum transfer in turbulent flow -**

Comparison of laminar and turbulent flows, mechanism of turbulence, intensity of turbulence, scale of turbulence, Reynold's stresses, the time smoothed velocity profile near the wall, Prandtl's mixing length model.

Analogies: Reynolds analogy, Prandtl's analogy, Chilton and Colburn analogy & Martinnelli's analogy.

**COURSE OUTCOMES: Students will able to**

1. Understand the analogy between momentum, heat and mass transfer.

2. Formulate a mathematical representation of a flow, heat and mass transfer phenomena.

3. Solve flow, heat and mass transfer problems either individually or coupled for simple geometries analytically.

4. Identify the similarities among the correlations for the flow, heat and mass transfer at interfaces.

5. Study and understand unsteady momentum transport and equations of change for isothermal systems.

**TEXT BOOKS:**

1. Transport Phenomena, Bird R. B., Stewart and Lightfoot, 2nd Edition, John Wiley & Sons.

2. Momentum, heat and mass transfer, Bennett C. O, Mayors J.E, Mc-Graw Hill, New York.

**REFERENCES:**

1. Transport phenomena, B.M. Suryavanshi, L.R. Dongre, Nirali Publications.

2. Transport Phenomena , P.L.V.N. Saichandra, Shrikant Barkade, Denett & Co.

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# (AUTONOMOUS)

| IV B.Tech. – I Sem | L | T/P/D | C |
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## DESIGN & ANALYSIS OF EXPERIMENTS

**PREREQUISITE:** Probability & Statistics

**COURSE OBJECTIVES**

The objective is to provide the student

1. With the basic need of experimental design and analysis of data
2. To familiarize various models (randomization, replication and blocking) and the analysis of resulting data by various means.
3. To make well equipped to apply these methodologies in chemical & Industrial sciences.
4. How to conduct analysis regarding various experimental methodologies
5. How subsequent course in regression analysis should deepen the experience.

**UNIT I:**

**I**ntroduction to Testing of Hypothesis [Definitions and Concepts/Theory only of Null Hypothesis & Alternative Hypothesis, tail test]. Introduction to Design of Experiment: Principles of an Experimental Design [Randomness, Replication and Local Control].

Design Terminology [Block, Degree of freedom, Confounding, Design, Effect, factor space, factor, Main effect, Interaction, Level]. Review of ANOVA [Basic assumptions, Concepts of ANOVA tables for one-way and two-way with problems]

**UNIT II:**

Factorial Experiment: [Definition and Concepts/Theory of Factor Effect, Fixed, Random Mixed Factor Effect]. Only Concepts/Theory of [Completely Randomized Design, RBD and LSD Recollection, Graeco-Latin Squares *no problems*].

**UNIT III:**

Factorial design; Concept/Theory of analysis of $2^k$ factorial designs. Analysis of $2^2$, $2^3$ and $2^4$ factorial designs. [Concept of ANOVA table Problems]. Confounding in Factorial Designs, confounding in $2^3$ and $2^4$ factorial design.

**UNIT IV:**

Concept/Theory of Analysis of $3^k$ factorial design. , Analysis of $3^2$ and $3^3$ factorial design [Concept of ANOVA table Problems] , Confounding in $3^3$ factorial design. Introduction to Balanced Incomplete Block Design. Analysis of Balanced Incomplete Block design BIBD [Concept of ANOVA table Problems].

**UNIT V:**

Regression analysis-[Simple Linear Regression, Interval Estimation in Simple Linear Regression, Analysis of Variance of Simple Linear Regression, Lack of Fit of the Simple Linear Regression. Multiple Regression, Polynomial Regression, Nonlinear Regression *with Problems*].

Correlation [Definitions and Correlation in Linear and Multiple Regression].

**COURSE OUTCOMES:**

1. Understand the different philosophical approaches to experimental design and ANOVA techniques
2. Build appropriate statistical models for designed experiments, perform data analysis
3. Construct and analyse appropriate experimental designs for given problems by applying to $2^k$ factorial designs and Regression model to chemical engineering experimental problems.
4. Construct and analyse appropriate experimental designs for given problems by applying to $3^k$ factorial designs and Regression model to chemical engineering experimental problems.
5. Able to apply and analyse regression analysis to factorial experiments and predict lack of fit for different systems.

**TEXT BOOKS:**

1. Design and analysis of experiments, 2nd ed., D.C. Montgomery, John Wiley and sons, New York, 2003.

2. Statistical Design and Analysis of Experiments with Applications to Engineering and Science, Second Edition, Robert L. Mason, Richard F. Gunst and James L. Hess, A John Wiley & Sons Publication.

**REFRENCES:**

1. Design of Experiments in Chemical Engineering, Zivorad R. Lazic, Wiley
2. Experimental Design and Data Analysis for Biologists, Gerry P. Quinn and Michael J. Keough, Cambridge University Press.
3. Dean Voss :- Design and Analysis of Experiments
4. Design of Experiments for Engineers and Scientists, Jiju Antony, Elsevier.

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# (AUTONOMOUS)

**IV B.Tech. – I Sem**

| L | T/P/D | C |
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## COMPUTATIONAL FLUID DYNAMICS

**PREREQUISITES:** Engineering mathematics, fluid mechanics and heat transfer

**COURSE OBJECTIVES:**

1. To make the students to demonstrate competence in setting up computational fluid dynamics models for some industrially important applications.
2. To apply finite difference approximation to various systems.
3. To acquire basic knowledge on Finite volume method
4. To compute the velocity and pressure fields using SIMPLE and PISO algorithms.
5. To understand the various grid generation techniques.

**UNIT-I**

**INTRODUCTION AND CONSERVATION LAWS and TURBULENCE MODELS**: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering. Models of the flow, substantial derivative, divergence of the velocity, continuity equation, momentum equation, energy equation, physical boundary conditions. Time marching and space marching problems. Characteristics of turbulent flows, time averaged, Navier Strokes equations, turbulence models-one and two equations, Reynolds stress, LES and DNS.

**UNIT-II**

**FINITE DIFFERENCE APPROXIMATION:** Mathematical behavior of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods, error and stability analysis.

**UNIT-III**

**FINITE VOLUME METHOD:** Diffusion problems- explicit and implicit time integration; Convection -diffusion problems- properties of discretization schemes, central, upwind, hybrid, QUICK schemes; Solutions of discretized equations.

**UNIT-IV**

**FLOW FIELD COMPUTATION**: Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows.

**UNIT-V**

**GRID GENERATION:** Grids With Appropriate Transformation: General transformation of the equations, Metrics and Jacobians of Transformation, Grid generation techniques, algebraic techniques, Elliptic grid generators, coordinate system control, hyperbolic grid generation techniques and parabolic generators.

**COURSE OUTCOMES:**

1. Apply conservation laws to different systems.
2. Solve partial differential equations in terms of finite difference equations.
3. Understand the finite volume method
4. Solve fluid flow problems applying different algorithms
5. Generate grids for different domains.

**TEXT BOOKS**

1. Anderson, J.D., "Computational Fluid Dynamics: The Basics with Applications". Mc Graw-Hill, 1995.

2. Hoffman, K.A., and Chiang, S.T., *Computational Fluid Dynamics*, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000

3. Versteeg, H.K. and Malasekera, W., "Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education Ltd., 2007.

**REFERENCE BOOKS**

1. Chung T.J Computational Fluid Dynamics Cambridge University Press, 2003.
2. Muralidhar, K., and Sundararajan T., "Computational Fluid Flow and Heat Transfer" Narosa Publishing House, New Delhi, 2001.
3. Ghoshdastidar P.S., "Computational Simulation of flow and heat transfer" Tata Mc Graw-Hill Publishing Company Ltd, 1998.
4. Subas, V. Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation, 1980.
5. Taylor, C and Hughes J.B., "Finite Elements Programming of the Navier Stoke Equation", Pineridge Press Ltd, 1981.

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| IV B.Tech. – I Sem | L | T/P/D | C |
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## TECHNOLOGY OF FUEL CELLS AND BATTERIES

**PREREQUISITES**: None

**COURSE OBJECTIVES: Students will be able**

1. To introduce the fundamentals of fuel cells
2. To understand the fuel cell electrochemistry
3. To learn fuel cell process design
4. To understand electrochemistry of the various primary batteries.
5. To analyze applications of secondary batteries.

**UNIT-I:**

Overview of Fuel cells: what is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.

**UNIT-II:**

Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others. Fuel cell electrochemistry: electrode kinetics, types of voltage losses, polarization curve, fuel cell efficiency, Tafel equation, exchange currents.

**UNIT-III:**

Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operation conditions: pressure, temperature, flow rates, humidity. Fuel processing: Direct and in-direct internal reforming, reformation of hydrocarbons by steam, $CO_2$ and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs.

**UNIT-IV:**

Batteries: Principles of operation, electrochemical principles and reactions battery electrolytes factors affecting battery performance. Primary batteries: introduction, Zinc-carbon batteries, Magnesium and Aluminum batteries, Lithium Primary batteries and Alkaline-Manganese batteries.

**UNIT-V:**

Secondary batteries: introduction, Lead-Acid batteries, Iron electrode batteries, industrial and aerospace Nickel-cadmium batteries and Lithium – Ion batteries and applications of batteries.

**COURSE OUTCOMES: Students will be able to**

1. Understand the fuel cell fundamentals
2. Analyze the performance of fuel cell systems
3. Understand construction of fuel cell and operation conditions
4. Have a firm knowledge on the primary batteries.
5. Understand the applications of secondary batteries.

**TEXT BOOKS:**

1. Hoogers., Fuel Cell Technology Hand Book, CRC Press, 2003.
2. Karl Kordesch & Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
3. F. Barbir, PEM Fuel Cells: theory and Practice, 2nd ed, Elsevier/Academic Press, 2013.
4. Linden, D.; Reddy, T.B , Handbook of Batteries, McGraw-Hill, 2002
5. Ronald Dell, David Anthony James Rand, Understanding Batteries, Royal Society of Chemistry, 2001

**REFERENCES:**

1. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, 2003.
2. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY 2006.

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## PROCESS DYNAMICS AND CONTROL LAB

**COURSE OBJECTIVES:**

1. To obtain transient response to disturbances like step, impulse, ramp and sinusoidal forcing function.
2. To analyze stability and performance of feedback loops using Laplace and frequency domain techniques.
3. To evaluate the first and second order system responses
4. To apply knowledge on interacting and non-interacting systems
5. Familiar with different types of advanced control strategies

**EXPERIMENTS:**

1. Calibration and determination of time lag of various first order instruments.
Major equipment: First order equipment like Mercury-in- Glass thermometer.

2. Calibration and determination of time lag of various second order instruments.
Major equipment: Second order equipment like Mercury-in- Glass thermometer with Thermal well.

3. Experiments with single and two capacity systems without interaction.
Major equipment: Single tank system, two tank systems

4. Experiments with single and two capacity systems with interaction.
Major equipment: Single tank system, two tank systems

5. Estimation of damping coefficient for U-tube manometer.
Major equipment: U-tube manometer.

6. Level Control Trainer.
Major equipment: Level control trainer setup with computer.

7. Temperature Control Trainer.
Major equipment: Temperature control trainer setup with computer.

8. Pressure Control Trainer.
Major equipment: Pressure control trainer setup with computer

.
9. Cascade control trainer.
Major equipment: Cascade control setup.

10. Control valve Characteristics.
Major equipment: Control valve setup.

**COURSE OUTCOMES**: Students will be able to

1. Understand and be able to describe quantitatively the dynamic behavior of process systems
2. Have knowledge on the development and use of right type of control dynamics for process control under different operative conditions.
3. Analyze the usage of control valve characteristics for different industries
4. Design control parameters for chemical systems.
5. Calculate dynamic parameters of chemical process systems.

**TEXT BOOKS:**

1. Process System Analysis and Control, 3rd Ed., D.R. Coughanowr and Steven E. Le Blanc, Mc Graw Hill, 2009.

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## PROCESS MODELING AND SIMULATION LAB

**COURSE OBJECTIVES:**

Students able to

1. Develop a sound working knowledge on FLUENT
2. Develop a sound working knowledge on MATLAB
3. Understand the Heat exchanger through simulation
4. Reaction Engineering simulations
5. Understand the Binary Distillation column Simulation

(At least **Ten** experiments out of the following 11 experiments should be performed)

**List of Experiments:**

The following experiments have to be conducted using MATLAB, FLUENT

MATLAB Scripts and function files

1. Gravity Flow tank.
2. Three CSTRs in series – open loop
3. Three CSTRs in series – Closed loop
4. Non isothermal CSTR
5. Binary Distillation column
6. Batch Reactor isothermal; Batch reactor non isothermal – closed loop
7. Isothermal batch reactor – open loop
8. Heat Exchanger
9. Interacting System- two tank liquid level
10. Non interacting system-two tank liquid level
11. Plug flow reactor

**COURSE OUTCOMES:**

1. Students would gain the practical knowledge about different Chemical software's
2. Students would gain the practical knowledge about Flowsheet making
3. Students able to understand the Heat exchanger through simulation
4. Students able to understand the Distillation through simulation
5. Students able to understand the Reactors through simulation

**TEXT BOOKS:**

1. Process Modeling Simulation and Control for Chemical Engineers by W. L. Luyben, McGraw Hill, 2nd Ed., 1990.

**REFERENCES:**

**1.** Computational Simulation tools in Engineering, V.Ramesh Kumar, T.Bala Narsaiah, K.Ravichand, B.S. Publications, 2018

**2.** A Guide to MATLAB for Chemical Engineering Problem Solving, Kip D. Hauch Introduction to Chemical Engineering Computing, Bruce A.Finlayson, Wiley-India Edn, 2010

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## PROJECT MANAGEMENT

**COURSE OBJECTIVES: Student will be able**

1. To understand the concept of Project Management.
2. To know about the different approaches to project screening and planning.
3. To explain about the factors of risk involved in project execution.
4. To understand about team leading and functional cooperation.
5. To know about the project performance and future trends in the project management.

**UNIT-I**

**Introduction:** Meaning, Need, Principles Project Lifecycle and its Phases, Project Management Research in brief, Project Management today, Organization strategy and structure and culture, Format of organization structure, Stake holder Management, Organization Culture, creating a culture for Project Management.

**UNIT-II**

**Project Identification and Planning:** Defining the project, Project Identification Process, Approaches to Project Screening and Selection, Project Planning, Work Breakdown Structure, Financial Module, Getting Approval and Compiling a Project Charter, setting up a Monitoring and Controlling Process.

**UNIT-III**

**Project Execution:** Initiating the Project, Controlling and Reporting Project Objectives, Conducting project evaluation, Risk, Risk Management Factors, Project Management, Four Stage Process, Risk Management an Integrated Approach, Cost Management, Creating a Project Budget.

**UNIT-IV**

**Leading Project Teams:** Building a Project Team, Characteristics of an effective Project Team, achieving Cross- Functional Co-operation, Virtual Project Teams, Conflicts Management, Negotiations.

**UNIT-V**

**Performance Measurement and Evaluation:** Monitoring Project Performances, Project Control Cycles, Earned Value Management, Human factors in Project Evaluation and Control, Project Termination, Types of Project Terminations, Project Follow-up. Current and Future Trends in Project Management.

**COURSE OUTCOMES:** At the end of the course students will be able to

1. Explain about the life cycle and other concepts of Project Management.
2. Apply different approaches to project screening and planning
3. Analyze different risk factors in project execution
4. Estimate how to lead a team, to get functional cooperation
5. Build performance evaluation reports and future trends in project management.

**TEXT BOOKS:**

1. Gray, Larson, Project Management, Tata McGraw Hill, 2015
2. Jeffery K. Pinto, Project Management, Pearson Education, 2015

**REFERENCES**

1. Enzo Frigenti, Project Management, Kogan, 2015
2. R. Panneerselvam & P. Senthil Kumar, Project Management, PHI, 2015
3. Thomas M. Cappels, Financially Focused Project Management, SPD, 2008.

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**IV B.Tech. – II Sem**

| L | T/P/D | C |
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## LOGICAL REASONING, VERBAL AND QUANTITATIVE ABILITY

**Pre requisites:** Basic Mathematics, Statistics and English

**COURSE OBJECTIVES:**

- To impart the knowledge of logical reasoning and aptitude
- To understand the number system and data sufficiency
- To sharpen the brains of students about the general aptitude

**Unit I:**

**Number Systems:** Classification of numbers, Squares, Fractions, Simplifications, Divisibility Test, Power Cycle, Reminder Cycle, Factors, LCM, HCF, Application of LCM & HCF

**Ratio and Proportion:** Tricks to solve ratio, proportions, continuous proportions, Variations, Ages

**Percentages:** Percentage Increase/ Decrease , Results on population , Results on Depreciation, Simple Interest , Principal , Interest , Amount , Application of Simple Interest, Compound Interest , Compound Annually , Compound Half-yearly , Compound Quarterl, Difference between Compound Interest and Simple Interest

**Unit II:**

**Geometry:** Lines , Properties of lines , Triangles, Properties of Triangles, Angles , Sectors , Chords , Planes , Quadrilateral

**Mensuration:** Area & Perimeter of Triangle, Quadrilateral, Rectangle, Square, Parallelogram, Trapezium, Surface Area & Volume of 3D Figures

**Data Interpretation:** Table Charts, Pie Charts, Bar Graphs, Line Graphs

**Data Sufficiency:** Problems On all quant and Logical topics

**Unit III:**

**Seating Arrangement:** Circular arrangement, row arrangement, column arrangement, Square arrangement, Double row arrangement

**Syllogisms:** Two Statements & Conclusion, Three Statements & Conclusion, Six Statements

**Unit IV:**

**Number Series:** Letter Series, Number Series, Letter & Number Series

**Analogy:** Simple Analogy, Double Analogy, Word Analogy, Number Analogy, Choosing Analogy Pairs

**Coding & Decoding:** Letter Coding, Number Coding, Symbol Coding, Letter - Number Coding, Letter - Symbol Coding, Direct Coding, Indirect Coding

**Blood Relations**: Based on Dialogue or conversation, Based on puzzles

**Unit V:**

**Nouns**: Types of nouns, rules, usages and error spotting

**Pronouns:** Types of nouns, rules, usages and error spotting

**Articles:** Definite and indefinite articles, Omission of articles, rules, usage and error spotting

**Adjectives and Adverbs**: Types of nouns, rules, usages and error spotting

**Preposition**: Types of nouns, rules, usages and error spotting

**COURSE OUTCOMES:**

On successful completion of this course, it is expected that the students will be able to,

1. Develop knowledge of general aptitude and logical reasoning
2. Improve the knowledge of arithmetical reasoning data sufficiency
3. Sharpen the brain in puzzle tests and jumbled problems

**TEXT BOOKS:**

1. Verbal and Non Verbal Reasoning by R.S.Agarwal.
2. Quantitative Aptitude by R.S.Agarwal.
3. Quantitative Aptitude by Abhijit Guha.

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| L | T/P/D | C |
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## ESSENTIAL ENGLISH & EMPLOYABILITY SKILLS

1. **Introduction:**

The purpose of graduate education is not only to gain knowledge but also to acquire employability skills fit for the qualification. The challenge of fresh graduates does not end with merely acquiring a job but to maintain credibility and sustainability throughout their career. Hence, varied skills and competencies are the pre-requisites for professional students who emerge from colleges and are ready to take up global careers.

**2. Objectives**:

a. To enable students to develop their personality, infuse confidence and increase employability skills in any chosen career.
b. To provide the students hands-on experience to cope with the demands of the world of recruiters.
c. To help the students acquire the job skills essential for employment.

**3. Learning Outcomes:**

a. Enhancement of employability skills and professional etiquette.
b. Acquisition of productive knowledge, competent learning and innovative thinking skills.
c. Implementation of verbal and non-verbal communication competencies in work place.

**Textbooks Prescribed:**
**Textbook 1: "English for Employability"** by **K Purushotham** published by **Orient Black Swan, Hyderabad**
**Textbook 2: "Personality Development and Soft Skills"** by **Barun K.Mitra,** published by **Oxford University Press**

**UNIT-I**

**"Six Sigma: Dabbawala"** from **"English for Employability"** by K Purushotham published by Orient Black Swan, Hyderabad, India.

**"Personality Development: A Must for Leadership and Career Growth"** from **"Personality Development and Soft Skills"** by Barun.K.Mitra, published by Oxford Publications -
Introduction, Learning about Personality Development from 3 Cases, Personality Analysis, Freudian analysis of Personality Development, Swami Vivekananda's Concept of Personality Development, Personality Begets Leadership Qualities.

**UNIT-II**
**"Yet I am not defeated!"** from **"English for Employability"** by K Purushotham published by Orient Black Swan, Hyderabad, India.

**"Interpersonal skills"** from **"Personality Development and Soft Skills"** by Barun.K.Mitra, published by Oxford Publications -
The Personality Attribute of Taking Bold Decisions, Personality Types and Leadership Qualities, Personality Tests

**UNIT-III**
**"Patricia Narayanan: An Entrepreneur by accident",** from **"English for Employability"** by K Purushotham published by Orient Black Swan, Hyderabad, India.

**"Soft Skills: Demanded by Every Employer"** from **"Personality Development and Soft Skills"** by Barun.K.Mitra, published by Oxford Publications
Introduction to Soft Skills, Lessons from the 3 Case Studies, Change in Today's Work place; Soft Skills as a Competitive Weapon, Antiquity of Soft Skills, Classification of Soft Skills

**UNIT-IV**
**"Satya Nadella: CEO of Microsoft" from "English for Employability"** by K Purushotham published by Orient Black Swan, Hyderabad, India.

**"Interview Skills"** from **"Personality Development and Soft Skills"** by Barun.K.Mitra, published by Oxford Publications.

**UNIT-V**
**"Body Language Reveals Your Inner self and Personality"** from **"Personality Development and Soft Skills"** by Barun.K.Mitra, published by Oxford Publications -
Introduction, Emotions Displayed by Body Language , Handshake-The Most Common Body Language, Eyes-A Powerful Reflection of One's Inner Self, Entry to My Space – Personal Zones May Vary, Body Language Exhibited during Different Professional Interactions.

**References**:

1. Cottrell,Stella.*Skills for Success*.London:Palgrave Macmillan,2003.
2. *Enhancing English and Employability Skills*, State Board of Technical Education and Training, Hyderabad: Orient Blackswan Private Limited, 2012.

3. Knight,T.Peter and Mantz Yorke.*Assessment, Learning and Employability*.U.K:Mac Graw-Hill House,2003.
4. Rao,M.S. *Soft Skills Enhancing Employability*.New Delhi: I.K.Publishing House,2010.
5. Rao, Nageshwar.Communication *Skills.* New Delhi: Himalaya Publishing House Pvt.Ltd, 2008.
6. Sharma,T.K.Enhancing Employability in Education.India:Patridge Publishing House.2015.
7. Sharma,T.K.Enhancing Employability in Education.India:Patridge Publishing House.2015.
8. Sinha, K. K.*Business Communication.NewDelhi*: Galgotia Publishing Company ,2008.
9. Yadav, Shalini. *Communication Techniques,* New Delhi: University Science Press,2010.

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| L | T/P/D | C |
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## MACHINE LEARNING

**Prerequisites:** Data Structures, Probability and statistics.

**COURSE OBJECTIVES:**
To understand the need for machine learning for various problem solving

1. To study the various supervised, semi-supervised and unsupervised learning algorithms in machine learning
2. To understand the latest trends in machine learning
3. To design appropriate machine learning algorithms for problem solving

**UNIT I : INTRODUCTION**

Learning Problems – Perspectives and Issues – Concept Learning – Version Spaces and Candidate Eliminations – Inductive bias – Decision Tree learning – Representation – Algorithm – Heuristic Space Search.

**UNIT II : NEURAL NETWORKS AND GENETIC ALGORITHMS**

Neural Network Representation – Problems – Perceptrons – Multilayer Networks and Back Propagation Algorithms – Advanced Topics – Genetic Algorithms – Hypothesis Space Search – Genetic Programming – Models of Evaluation and Learning.

**UNIT III : BAYESIAN AND COMPUTATIONAL LEARNING**

Bayes Theorem – Concept Learning – Maximum Likelihood – Minimum Description Length Principle – Bayes Optimal Classifier – Gibbs Algorithm – Naïve Bayes Classifier – Bayesian Belief Network – EM Algorithm – Probability Learning – Sample Complexity – Finite and Infinite Hypothesis Spaces – Mistake Bound Model.

**UNIT IV : INSTANT BASED LEARNING**

K- Nearest Neighbour Learning – Locally weighted Regression – Radial Basis Functions – Case Based Learning.

**UNIT V : ADVANCED LEARNING**

Learning Sets of Rules – Sequential Covering Algorithm – Learning Rule Set – First Order Rules – Sets of First Order Rules – Induction on Inverted Deduction – Inverting Resolution – Analytical Learning – Perfect Domain Theories – Explanation Base Learning – FOCL Algorithm – Reinforcement Learning – Task – Q-Learning – Temporal Difference Learning

**COURSE OUTCOMES**:

Student will be able to:

1. Differentiate between supervised, unsupervised, semi-supervised machine learning approaches
2. Discuss the decision tree algorithm and identity and overcome the problem of overfitting
3. Apply the back propagation algorithm and genetic algorithms to various problems
4. Usage of Bayesian concepts to machine learning
5. Analyse the appropriate machine learning approaches for various real time problems

**TEXT BOOK:**

1. Tom M. Mitchell, ―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.

**REFERENCES:**

1. Ethem Alpaydin, ―Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press 2004.
2. Stephen Marsland, ―Machine Learning: An Algorithmic Perspective, CRC Press, 2009.

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**IV B.Tech. – II Sem** | **L** | **T/P/D** | **C**
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## INTERNET OF THINGS

**Prerequisites:** Computer networks and operating systems

**Course Objectives:**

1. To understand the basics of Internet of Things
2. To get an idea of some of the application areas where Internet of Things can be applied
3. To understand the middleware for Internet of Things
4. To understand the concepts of Web of Things
5. To understand the concepts of Cloud of Things with emphasis on Mobile cloud computing

**UNIT I:**

**Introduction to Internet of Things (IoT)** - Definition and characteristics of IoT, Physical Design of IoT, Logical Design of IoT, IoT Enabling Technologies, IoT Levels and Deployment Templates.

**UNIT II :**

Domain Specific IoTs Introduction, Home Automation, cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health and Lifestyle.

IoT and M2M Introduction to M2M, Difference between IoT and M2M, SDN and NFV to IoT. Basics of IoT System Management with NETCOZF, YANG NETCONF, YANG, SNMP NETOPEER

**UNIT III :**

Developing Internet of Things: IoT Platform Design Methodology, Introduction, IoT Design Methodology, Case Study on the IoT System for Whether Monitoring, Motivation for using Python.

**UNIT IV :**

IoT Systems –Logical Design using Python, Introduction, Installing Python, Python Data Types and Data Structures, Control Flow and Functions, Modules , Packages, File Handling, Date/Time Operations, Classes, Python packages of Internet of Things,JSON,XML,HTTP,Lib and URL lib, SMTP lib.

**UNIT V:**

IoT Physical Device and Endpoints, What is an IoT Device, Exemplary Device: Raspberry $P_i$ About Raspberry Board, Linux on Raspberry $P_i$ ,Raspberry $P_i$ Interfaces, Serial, SPI, I2C. Programming Raspberry $P_{i\ with}$ Python, Other IoT Devices.

**Course Outcomes:**

Student will be able to:

1. Identify and design the new models for market strategic interaction
2. Design business intelligence and information security for WoB
3. Analyze various protocols for IoT
4. Design a middleware for IoT
5. Analyze and design different models for network dynamics

**Text Book:**

1. ArshdeepBahga and Vijay Madisetti,Internet of Things A Hands –on approach, Universities Press, 2015.

**Reference Books:**

1. HonboZhou,The Internet of Things in the Cloud: A Middleware Perspective, CRC Press, 2012
2. Dieter Uckelmann, Mark Harrison, Florian Michahelles, Architecting the Internet of Things, Springer – 2011
3. David Easley and Jon Kleinberg,Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press, 2010
4. Olivier Hersent, Omar Elloumi and David Boswarthick,The Internet of Things: Applications to the Smart Grid and Building Automation, Wiley, 2012

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| L | T/P/D | C |
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## PYTHON PROGRAMMING

**Prerequisites:** Any programming language

**Unit – I**

**Introduction to Python:**
Features of Python Language, Data Types, Operators, Expressions, Control Statement, Standard I/O Operations

**Functions and Modules:**
Declaration and Definition Function Calling, More on Defining Functions, Recursive Functions, Modules, Packages in Python, Doc Strings, Built-in Functions,

**Unit – II**

**Strings and Regular Expressions:**
String Operations, Built-in String Methods and Functions, Comparing Strings, function in Regular Expression.
**Sequence:**
List, Tuples, Dictionaries.

**Unit – III**

**Implementation of classes and objects in Python:**

Classes and Objects, Class Method and Self Argument. The __Init__Method, Class Variables and Object Variables, The _Del__Method, Public and Private Data Members, Private Methods, Buil-in Functions to Check, Get, Set and Delete Class Attributes, Garbage Collection(Destroying Objects).

**Unit – IV**
**Implementation of Inheritance in Python:**
Inheriting Classes in Python, Types of Inheritance, Composition/Containership, Abstract Classes and Interfaces, Meta class,

**Implementation of Operator Overloading in Python:**
Introduction, Implementing Operator Overloading, Overriding Methods

**Unit – V**

**Exception Handling in Python:**
Introduction, Handling Exception, Multiple Except Blocks and Multiple Exceptions, Finally Block.

**Python Packages:**
Introduction to Numpy, Pandas, Matplotlib, Tkinter

**COURSE OUTCOMES: Students will be able to**

1. Identify the differences between scripts and programs
2. Solve the problems based on decision control statements
3. Develop programs on functions and data structures.
4. Write the programs on string operations
5. Use of python exceptions and packages

**Text Books**

1. "ReemaThareja", Python Programming using Problem Solving Approach, First Edition, Oxford Higher Eduction.

2 James Payne, Beginning Python using Python 2.6 and Python 3

**Suggested / Reference Books**

1 Kenneth A.Lambert, Fundamentals of Python

2 Charles Dierach, Introduction to Computer Science using Python