Course Objective:
To make the students understand the basic concepts of fluids and fluid flow which are essential in majority of the engineering applications. After undergoing this course the students will have the knowledge of various pressure measuring instruments, Fluid statics, Types of fluid motion, Fluid dynamics, Pipe flow, The concept of boundary layer, Lift and drag etc.

UNIT-I
Basic fluid concepts, Velocity and stress fields, Classification of fluids. Basic equation for pressure field, Manometers.
Dimensional Analysis, Methods of dimensional analysis.

UNIT-II
Fluid Flow Phenomena, Types of flows, Methods of analysis.
Flow Through Pipes, Introduction to turbulent flows, K factors, Valves, Pipe networks.

UNIT-III
Flow Measuring Devices, Impinging jet, Pitot tube, Orifice meter, Rotameter, V-notch, Water current meter etc.
Pumps and Compressors, Types, Working, Basic equations.

UNIT-IV
Agitation and Mixing of Liquids, Power consumption, Mixing times, Scale up.
Flow Through Coils, Helical coils and spherical coils.

Recommended Books,
- Kumar D S, Fluid Mechanics and Fluid power Engineering, Katson Publications
- McCabe W, Smith J and Harriott P, Unit Operations of Chemical Engineering, McGraw-Hill
- Fox R W, MacDonald A T and Pritchard P J, Introduction to Fluid Mechanics, Wiley & Sons Inc
- Denn M, Process Fluid Mechanics, Prentice Hall
Course Objective:
To make the students understand the basic concepts of mechanical operations which are essential in majority of the engineering applications. After undergoing this course the students will have the knowledge of Particle Size Analysis, Size Reduction, Storage of Solids, Particle Mechanics, Sedimentation and Floatation, Flow Through Packed Beds, Fluidization, Filtration, Fluid-Solid Conveying etc.

UNIT-I
Determination of mean particle size, Particle shape, And particle size distribution, Screening, Types of screens, Screen effectiveness and efficiency, Particle size analysis using screens, Size Reduction, Principles of crushing and grinding, Laws of size reduction, Industrial size reduction equipment, Closed and open circuit grinding.

UNIT-II
Fluid-Solid Separations, Stoke's law, Free and hindered settling, Clarifiers and thickeners, Settling chambers, Elutriation, Bag filters, Electrostatic precipitators, Froth-flotation, Magnetic separators, Centrifugal separators, Flow Past Immersed Bodies, Friction in flow through beds of solids,, Motion of particles through fluids.

UNIT-III
Fluidization, Mechanism of fluidization, Determination of minimum fluidization velocity, Determination of velocity range for the operation of a fluidized bed, Types of fluidization, Applications of fluidization.
Filtration, Theory of filtration and filtration equipment.

UNIT-IV
Handling of Solids, Storage of solids, Sizing of hoppers and bins, Mechanical, Pneumatic and hydraulic conveying systems, Mixing of solids and power index.

Recommended Books:
- Narayanan C M and Bhattacharya B C, Mechanical Operations for Chemical Engineers, Khanna Publishers
**Course Objective:**
The aim of the course is to study process technologies, Availability of raw materials, Production trends, Material and energy balances, Flow sheets, Engineering problems pertaining to materials of construction, Waste regeneration/recycling, Environmental and energy conservation measures, For various inorganic chemical industries.

<table>
<thead>
<tr>
<th>UNIT-I</th>
<th>Introduction to Chemical Engineering, Unit operations and unit processes, Functions of a chemical engineer in chemical and bio-chemical process industries. Industrial and Fuel Gases, Oxygen, Nitrogen, Hydrogen, Carbon dioxide, Natural gas, LPG, Producer gas, Water gas, Carbureted water gas, Coke oven gas, Synthesis gas.</th>
</tr>
</thead>
</table>

**Recommended Books:**
- Rao M G and Sittig M, Dryden’s outlines of Chemical Technology-For the 21st century, Affiliated East West Press
- Austin G T, Shreve’s Chemical Process Industries, McGraw-Hill
- Faith W L, Keyes D B and Clark R L, Industrial Chemicals, John Wiley
Course Objective:
This course covers the application of different computational techniques for solving and analyzing the chemical engineering problems.
The first part of this course begins with the introduction to matrix algebra and numerical techniques. Attention has been paid to the analysis of linear and nonlinear system behaviors.
The second part of the course is designed to give students the ability to develop mathematical models and to obtain numerical solution of steady-state and unsteady-state problems related to chemical engineering systems.

UNIT-I
Errors, classification, Significant digits and numerical stability, Linear algebraic equations, Cramer’s rule, Gauss elimination, Decomposition Gauss-Jordan elimination, Gauss-Seidel and relaxation methods.

UNIT-II

UNIT-III
Function evaluation, least squares curve-fit (linear regression), Newton’s interpolation formulae (equal intervals), Newton’s divided difference interpolation polynomial, Lagrangian interpolation unequal intervals), Differentiation formulae, Integration formulae or quadratures (trapezoidal, Simpson’s 1/3 and 3/8 rules), Extrapolation technique of Richardson and Gaunt.

UNIT-IV
Ordinary differential equations (initial value problems and boundary value problems), the finite difference technique. Introduction of finite element methods.

Recommended Books:
- Villadsen J, And Michelsen M L, Solution of Differential Equation Models by Polynomial approximation, Prentice Hall, N J
- Richard G Rice & Duong D Do, Applied Mathematics and Modeling for Chemical Engineers, John Wiley & Sons, Inc
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-209  MATERIAL AND ENERGY BALANCES

Course Objective:
To teach students fundamental knowledge of chemical engineering and application of this knowledge in the solving of material and energy balances of chemical processes. After undergoing this course the students will have the knowledge of basics such as units and dimensions, Stiochiometry to the simultaneous application of material and energy balances with and without occurrence of chemical reaction, Behaviour of ideal gases including the procedures for estimation of vapour pressure and heats of vaporization, Humidity and saturation along with the use of humidity chart and steam tables.

UNIT-I
Introduction, Role of chemical engineering in industry, Schematic flow sheets including symbols, Unit operations and unit processes with reference to MEB calculations. Introduction to units systems, Units and dimensions, Mole, Specific gravity, Specific volume, Concentrations, Stoichiometry of chemical equations, Mole fraction and weight fraction, Degrees of freedom.

UNIT-II

UNIT-III

UNIT-IV

Recommended Books:
• Himmelblau D M, Basic Principles and Calculations in Chemical Engineering, Prentice Hall of India
• Bhatt B I, And Vora S M, Stoichiometry, Tata McGraw-Hill
• Felder R M and Rousseau R W, Elementary Principles of Chemical Processes, John Wiley
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
HS-201    ESSENTIALS OF MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR

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Course Objective:
To help the students lay a foundation to an understanding of Management and Organizational behavior which are essential fields of study to make a success of both their professional and personal lives.

UNIT-I
Concept of management, Characteristics and Importance, Management vs Administration, Management as an art a science and as a profession, Levels of Management, Contributions of Henry Fayol, FWTaylor & Elton Mayo, Management Functions, Planning, Organizing, Staffing, Directing and Controlling.

UNIT-II
Concept & significance of Organizational Behavior, Challenges and opportunities in the field of OB, Model of OB. Learning, Attitude, Job Satisfaction, Personality, Perception and Individual Decision-making, Motivation, Theories of Motivation by Maslow, Herzberg and McGregor.

UNIT-III
Classification of Groups, Stages of Group Development, Group Properties, Group Decision-making.
Types of Teams, Creation of an Effective Team, Difference between a group and a team.
Styles of Leadership, Theories of Leadership by Blake and Mouton, Contingency Theory by Fiedler.

UNIT-IV

Recommended Books:
- Koontz , Essentials of Management, Tata McGraw Hill
- Robbins and Coulter, Management, PHI, 8th Ed.
- Robbins and Judge, Organizational Behavior, Pearson
- Pareek, Understanding Organizational Behavior, Oxford
- Luthans, Organizational Behaviour, McGraw Hill Education
EXPERIMENTS

- Verification of Bernoulli’s theorem
- Calibration of venturimeter
- Calibration of orifice meter
- Determination of friction factor for pipes of different materials
- Determination of hydraulic coefficients of an orifice
- Determination of loss coefficients for various types of pipe fittings
- Calibration of a triangular notch
- Calibration by Rotameter
- Characteristic curves of centrifugal pumps
- Determination of stability of floating body
- Measurement of losses due to contraction and expansion
- Verification of laminar/turbulent flow regime in a flow process
## CHE-213 MECHANICAL OPERATIONS LAB

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**Internal Evaluation: 25 Marks**  
**External Examination: 25 Marks**  
**Duration of Examination: 03 Hours**

### EXPERIMENTS

- Verification of Stokes Law.
- Screen analysis of given sample for it’s particle size distribution.
- Determination of variation in pressure drop & bed height w.r.t superficial velocity for a bed of solids.
- Determination of minimum fluidization velocity for a bed of solids.
- Operating characteristics of crushing and grinding equipments (Jaw crusher, Roll crusher)
- Determination of %age recovery of coal in froth from coal and sand mixture.
- Determination of thickener capacity using batch sedimentation.
- Determination of the separation efficiency of the classifier.
- To determine filtration constants for a given slurry in the Leaf filter.
- To plot power function Vs. Reynolds number for various size of impellers in agitated vessel.
- To study the specific rate of breakage of a particular feed size of the given feed material in the lab scale ball mill.
- To plot characteristics curves for centrifugal pump.
- To determine crushing law constant by using Rittinger’s law, Bond’s law and Kick’s law.
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE-217  NUMERICAL METHODS IN CHEMICAL ENGINEERING LAB

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Internal Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

EXPERIMENTS

- Solution of a system of linear equations in unknowns by Gaussian elimination.
- Gauss-Seidel iterative method to solve a linear system of equations.
- To find the inverse of matrix by Gauss-Jordan method.
- Application of Faddeev-Leverrier's method.
- Method for finding dominant Eigen value and corresponding Eigen vectors by power method.
- Solution of nonlinear equation by Newton Raphson method.
- Application of Newton's formulae for interpolation.
- Application of LaGrange polynomial interpolation formula.
- Application of Newton's formula for numerical differentiation.
- Numerical integration by Trapezoidal rule.
- Numerical integration by Simpson's rules.
- Application of finite difference technique.
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ELGA-201  ENGLISH LANGUAGE AND GENERAL AWARENESS-III

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Course Objective:
To help the students acquire the ability to develop a well-structured paragraph and also to provide them basic knowledge of issues relating to poverty in India.

UNIT-I
Paragraph Development
- Guidelines for effectiveness of a paragraph
- Fog Index (an indication of clarity of any text) by Robert Gunning
- Expanding an idea into a paragraph

UNIT-II
General Awareness
(a) Poverty in India
- The concept of poverty
- Various estimates of poverty
- Economic reforms and reduction of poverty
- Poverty eradication programs: a review
(b) Biography: Ratan Tata
(c) Book Review: Ignited Minds by APJ Abdul Kalam
(d) Industry Overview: Small Scale Industries

Recommended Books:
- Barun K Mitra, Effective Technical Communication, Oxford
- Tyagi Kavita & Misra Padma, Basic Technical Communication, PHI
- Raman Meenakshi & Sharma Sangeeta, Technical Communication, Oxford
- Datt & Sundharam, Indian Economy, S Chand
- Sharma R C, Krishna Mohan, Business Correspondence and Report Writing, TMH
# CHE-202  INDUSTRIAL POLLUTION ABATEMENT

**Course Objective:**

The aim of this course that the students will learn the essential principles used in Industrial pollution abatement and understand important issues in Industrial pollution abatement and pertinent environmental legislations. After undergoing this course the students will have the knowledge of surface water and ground water quality and the remediation technologies, The design processes for treatment of environmental Pollutants, Indoor air pollution and control, As well as global atmosphere change.

<table>
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<tr>
<th>UNIT-I</th>
<th>Introduction, Industrial pollution, Different types of wastes generated in an industry, Different water pollutants, Air pollutants and solid wastes from industry, Their effects on living and non-living things, Environmental regulatory legislations and standards, Importance of industrial pollution abatement, Concept of sustainable development, Green house gases, Global warming and climate change.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIT-II</td>
<td>Water Pollution, Identification, Quantification and analysis of wastewater, Classification of different treatment methods into physico-chemical and biochemical techniques, Physico-chemical methods, General concept of primary treatment, Liquid-solid separation, Design of a settling tank, Neutralization and flocculation, Biological methods, Concept of aerobic digestion, Design of activated sludge process, Concept of anaerobic digestion, Biogas plant layout, Different unit operations and unit processes involved in conversion of highly polluted water to potable standards.</td>
</tr>
<tr>
<td>UNIT-III</td>
<td>Air Pollution, Classification of air pollutants, Nature and characteristics of gaseous and particulate pollutants, Analysis of different air pollutants, Description of stack monitoring kit and high volume sampler, Atmospheric dispersion of air pollutants, Gaussian model for prediction of concentration of pollutant down wind direction, Concept of temperature inversion, Plume and its behavior, Concept of effective stack height, Operating principles and simple design calculations of particulate control devices like gravity settling chamber, Cyclone, Bag filters, Electrostatic precipitators and scrubbers, Brief concepts of control of gaseous emissions by absorption, Adsorption, Chemical transformation and combustion.</td>
</tr>
</tbody>
</table>

**Recommended Books:**

- Rao C S, Environmental Pollution Control Engineering, Wiley Eastern
- Metcalf & Eddy, Wastewater Engineering, Tata McGraw-Hill Education Private Limited
- Masters G M, Introduction to Environmental Engineering and Science, Prentice hall off India
- De Nevers N, Air Pollution Control Engineering, McGraw-Hill.
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-204 HEAT TRANSFER

Internal Evaluation: 50 Marks  
External Examination: 50 Marks  
Duration of Examination: 03 Hours

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Course Objective:
To expose students to heat transfer applications in industry. After undergoing this course the students will have the knowledge of heat transfer principles, Behavior of thermal systems, Development of the governing differential, Algebraic and finite difference equations associated with thermal systems and to investigate the influences of boundary and initial conditions and system parameters on the resulting steady or transient response of the system.

UNIT-I  
Heat Transfer, Introduction, Applications, Relation between heat transfer and thermodynamics, And transport properties

UNIT-II  
Convection, (a) Natural convection. Heat transfer in laminar and turbulent flows inside tubes. Dimensional analysis, Boundary layer, Colburn analogy. Heat transfer by external flows across cylinders, Tube bank and spheres. (b) Convection with Phase Change, Condensation, Boiling and heat pipes.
Radiation, Basic equations, Emissivity, Absorption, Black and gray body, Thermal radiation between two surfaces.

UNIT-III  
Heat Exchangers, Classification, Introduction to LMTD and ε-NTU methods. Design of heat exchangers such as double pipe heat exchanger, Shell-and-tube exchanger, Plate heat exchangers, Compact heat exchangers, Fouling.

UNIT-IV  
Evaporators, Classification, Single and multiple effect evaporators, Enthalpy balance, Performance of evaporators such as capacity and economy, Methods of feeding.

Recommended Books:
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE-206  CHEMICAL TECHNOLOGY-II

Course Objective:
There has been continuous upgradation in technologies for improving the overall economy of the chemical processes. After undergoing this course the students will have the knowledge of various process technologies, Production trends, Material and energy balances, Flow sheets, Engineering problems pertaining to materials of construction, Waste regeneration/recycling, Environmental and energy conservation measures, For various organic chemical industries.

UNIT-I
Study of the following chemical industries/processes involving process details, Production trends, Material and energy balances, Flow sheets, Engineering problems pertaining to materials of construction, Regeneration/recycling, Environmental and energy conservation measures.


Coal and Coal Chemicals, Types of coal, Destructive distillation of coal, Distillation of coal tar, Chemicals from coal.

UNIT-II

Sugar and Starch Industries, Raw and refined sugar, Byproducts of sugar industries, Starch and starch derivatives.

UNIT-III
Oils and Fats, Types of oil, Different fatty acids, Extraction of oil from seeds, Oil purification, Hydrogenation of oil.

Soaps and Detergents, Types of soaps, Soap manufacture, Recovery and purification. Types of detergents, Their cleansing action.

Surface coating industries, Paints, Pigments, Varnishes, Industrial coatings
Food Industries, Food processing, Food additives and preservatives, Food processing equipments.

UNIT-IV
Fermentation and Enzyme Industries, Production of industrial alcohol, Acetic acid, Citric acid and lactic acid. Introduction to enzymes and their applications.

Polymers, Monomers, Thermoplastic and Thermosetting materials (such as polyethylene, Polypropylene, Polyster, and PF resins; Epoxy and polyesters - Natural rubber; Synthetic rubber such as SBR, NBR, CR - Fundamental methods of processing of synthetic Rubbers.

Synthetic fiber and Film Industries, Viscose rayon, Cuprammonium and cellulose acetate, Nylons, Polyesters, Acrylics.

Recommended Books:
- Rao M G and Sittig M, Dryden’s outlines of Chemical Technology—For the 21st century, Affiliated East West Press
- Austin G T, Shreve’s Chemical Process Industries, McGraw-Hill
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING

CHE-208  MASS TRANSFER-I

Course Objective:
The course covers mass transfer fundamentals such as diffusion, Film theory, Mass transfer rate and mass transfer coefficients for various different systems. In this course analogy between momentum, Heat and mass transfer is also covered. Further different types of equipments have also been covered for more industrial exposure, How the basis mechanism behind this equipment they work.

UNIT-I
Diffusion in Fluids, Molecular diffusion, Diffusion through stagnant gas film, Equation of continuity for binary systems, Correlation for diffusivity in gases and liquids for binary and multi-component systems, Mass Transfer Coefficients, Basic concepts and definitions of mass transfer coefficients ($k_G$, $k_L$, Etc.), Mass transfer coefficients for falling liquid film, Turbulent mass transfer and eddy diffusion, Theories of mass transfer.

UNIT-II
Analogy between momentum, Heat and mass transfer (Reynold's and Colburn's analogies), Simultaneous heat and mass transfer and prediction of wet-bulb temperature. Interphase Mass Transfer, Equilibrium curve, Diffusion between phases, Overall mass transfer coefficient, And Operating lines for co-current and counter-current operations, Theoretical stages and multistage cascading, Kremser equation for dilute gas mixtures.

UNIT-III
Mass transfer equipment like Wetted wall columns, Packed columns, Plate columns. Gas Absorption, Isothermal and adiabatic gas-liquid contact, Choice of solvents, Design of absorption towers, NTU, HTU, Gas absorption with chemical reaction.

UNIT-IV
Humidification and Dehumidification, Adiabatic saturation curves, Adiabatic saturation temperature, Wet bulb temperature and humidity, Cooling towers. Crystallization, Mechanism, Seeding, Particle size distribution, Classification of crystallizes. Drying, Mechanism and rate of drying, Calculations for batch and continuous drying, Types of dryers.

Recommended Books:
- McCabe W L, And Smith J C, Unit Operations of Chemical Engineering, McGraw Hill
- Dutta B K, Mass Transfer and separation process, Prentice Hall of India
- Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India
Course Objective:
The aim of this course is to understand the laws of thermodynamics and their application in the analysis of Chemical and engineering problems. After undergoing this course the students will have the knowledge of equations of state for calculating thermodynamics properties of fluids and fluid mixtures, Equilibrium compositions of chemical reactions and two-phase liquid/vapor mixtures.

UNIT-I

UNIT-II

UNIT-III
Vapor/liquid equilibrium and solution thermodynamics, Criteria for equilibrium. Fugacity of gases and liquids, Pure component and mixtures Composition of phases in equilibrium, Generalized correlations for the fugacity coefficients, Models for the excess Gibbs energy, Effect of pressure and temperature on phase behavior, Chemical Reaction Equilibria.

UNIT-IV

Recommended Books:
- Rao Y V C, Chemical Engineering Thermodynamics, University Press
- Weber H C & Meissner H P, Thermodynamics for Chemical Engineers, John Wiley & Sons Inc
Course Objective:

To provide the students a basic understanding of Business and Economics which are vital constituents of the overall professional environment of an Engineer.

UNIT-I


UNIT-II


UNIT-III


UNIT-IV

Meaning and significance of Economics, Role of economics in engineering and technology, Basic economic terms, Utility, Saving, Investment, Equilibrium, Micro and macro economics, Economic policies, Globalization, Privatization, Liberalization, Demand &Supply Analysis, Meaning of demand and supply, Law of demand and supply, Elasticity of demand and its measurement, Production, Factors of production, Law of variable production, Production function, Cost Analysis, Types of costs and shapes of different cost curves, Theory of Firm and Pricing, Types of markets, Equilibrium of firm and industry under perfect, Monopoly and imperfect competition.

Recommended Books:

- Dessler, Human Resource Management, Pearson
- Pandey I M, Financial Management, Vikas
- Kotler Philip, Marketing Management, Pearson
- Kotler Philip & Armstrong Gary, Principles of Marketing, Pearson
- Ahuja H L, Micro Economic Theory, S Chand
- Ruder Dutt & Sundharam, Indian Economy, S Chand
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE-212  INDUSTRIAL POLLUTION ABATEMENT LAB

Internal Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

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**EXPERIMENTS**

- Determination of Free CO₂ in a given sample of water.
- To determine alkalinity of given water sample is due to the presence of carbonate and hydroxide ion.
- Determination of acidity of a water sample.
- Ambient air quality measurement by high volume sampler (Particulate, SOₓ, NOₓ).
- Determination of sludge volume index.
- Determination of the percentage of CO₂, CO, O₂ and N₂ in a flue gas (or automobile exhaust) by Orsat’s apparatus.
- Determination of Phosphorus in waste water sample.
- Determination of ammonical as well as organic nitrogen in waste water sample.
- Estimation of fluoride.
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-214 HEAT TRANSFER LAB  

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**Internal Evaluation:** 25 Marks  
**External Examination:** 25 Marks  
**Duration of Examination:** 03 Hours

- To determine the thermal conductivity of insulating powdered material say asbestos powder.
- To determine the value of stein Boltzmann constant assuming black body concept placed at the centre of hemisphere.
- To determine the emissivity, Absorbtivity and reflectivity of the given non-black Aluminum surface at the various temperatures.
- To study the double pipe hair pin heat exchanger and to determine experimentally the above all heat transfer coefficients at various liquid Reynolds number and estimate the film heat transfer coefficients on Hot water side.
- To compute film heat transfer coefficients using standard equation and compare with those expt. obtained.
- To calculate the heat transfer coefficient in natural convection.
- Wilson Plots. Unsteady state heat transfer in jacketed vessels.
- Correlation of instantaneous heat transfer, Coefficients with time for steady deposition of scale on a heating surface.
- Heat losses from insulated pipes.
- Study and operation of long tube, Forced circulation and multiple effect evaporators.
- Duhring’s plot for solutions involving non-volatile solutes
- To find heat transfer coefficient for parallel flow and counter flow for double pipe heat exchanger.
- To find heat transfer coefficient loosing heat by forced convection to air flowing through it for different air flow rates & heat flow rates.
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING

CHE-216  CHEMICAL TECHNOLOGY LAB

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**Internal Evaluation: 25 Marks**

**External Examination: 25 Marks**

**Duration of Examination: 03 Hours**

**EXPERIMENTS**

- To perform proximate analysis of a given sample.
- Determination of HCV and LCV of a given fuel by bomb calorimeter.
- To determine the acid value of an oil/fat.
- To determine the saponification value of an oil/fat.
- To determine the iodine value of an oil/fat.
- To determine the neutralization no. of an oil/fat.
- Preparation of phenol-formaldehyde.
- Preparation of urea-formaldehyde.
- Preparation of soap using fatty acids and alkali.
- To carry out hydrogenation of a polyunsaturated oil.
- Preparation of an oil based paint.
- Determination of N-P-K Values of Fertilizers
- Determination of micronutrients of Fertilizers
- Cement: Loss of ignition, Silica, Insoluble's
- Estimation of Mg, Ca, Fe in cement.
Course Objective:
To help the students master the art of condensation this is an essential skill in technical communication and, through the General Awareness section, To sensitize the students on Human Development Index.

UNIT-I
Précis Writing
• Importance of précis in technical communication
• Essentials of an effective précis
• Steps to effective précis writing
• Précis writing exercises

UNIT-II
General Awareness
(a) Human Development in India
• The concept of Human Development
• Measuring human development
• India’s position in human development
• National Human Development Report
(b) Biography: Azim Premji
(c) Book Review: The World is Flat by Thomas L Friedman
(d) Industry Overview: Iron and steel

Recommended Books:
• Mitra Barun K, Effective Technical Communication, Oxford
• Tyagi Kavita & Misra Padma, Basic Technical Communication, PHI
• Raman Meenakshi & Sharma Sangeeta, Technical Communication, Oxford
• Datt & Sundharam, Indian Economy, S Chand
• Sharma R C, Krishna Mohan, Business Correspondence and Report Writing, TMH
Course Objective:
In the chemical process industry plant safety is important. Knowledge of plant safety is essential to prevent accidents and damages while working in plant. A safety audit and risk analysis prepares the plant operators and managers to develop a safe protocol and minimize potential damages to process equipments, People and the environment. This course will give an overview of the safety regulations and practices, Plant hazards and their control, Risk management principles and techniques and accident analysis.

UNIT-I
Plant Safety and Safety regulation, Importance & objectives of safety, Safety in chemical industry, Criteria for setting & layout of chemical plant. Factories Act and Safety Regulations.

UNIT-II

UNIT-III

UNIT-IV

Recommended Books:
- Vasandhani V P, And Kumar D S, Heat Engineering, Metropolitan Book Co. Pvt. Ltd
- Banerjee S, Industrial Hazards and Plant Safety, Taylor & Francis
- Sanders R E, Chemical Process Safety-Learning from Case Histories, Oxford
Course Objective:
This course provides the students a thorough introduction of fundamentals aspects of chemical kinetics and reactors. In this students will learn about different rate reactions, Their dependences on pressure, Temperature and other parameters. Further reactions conditions in various simple and complex reactors like CSTR, PFR and fluidized beds. Also different working conditions of single and multi reactions have also been covered in this course.

UNIT-I
Introduction, Overview of chemical reaction engineering, Classification of reactions, Variables affecting rate, Definition of reaction rate, Single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Reaction pathways, Effects of temperature, Pressure, Heat and mass transfer on rate, Arrhenius law, Activation energy, Reversible and irreversible reactions, Reaction equilibrium.

UNIT-II
Kinetics, Constant volume and variable volume batch, CSTR and PFR reactor data, Analysis of total pressure data obtained from a constant-volume batch reactor, Integral and differential methods of analysis of data, Autocatalytic reactions, Reversible reactions, And Bio-chemical reactions.

UNIT-III
Multiple Reactions, Parallel reactions of different orders, Yield and selectivity, Product distribution and design for single and multiple-reactors, Series reactions, first-order reactions and zero-order reactions, Mixed series parallel complex reactions, Choice of reactors for simple and complex reactions.

UNIT-IV

Recommended Books:
- Levenspiel O, Chemical Reaction Engineering, John Wiley & Sons
- Fogler H S, Elements of Chemical Reaction Engineering, Prentice Hall of India
### B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-305  MASS TRANSFER-II

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#### Course Objective:
This second course on mass transfer introduces the fundamental concepts, Principles and applications of mass transfer processes. The modeling, Design and performance calculation aspects of separation processes using rate-based and equilibrium stage based modeling approaches are then developed. After undergoing this course the students will have the knowledge of various separation processes absorption, Distillation, Extraction, Adsorption, Drying etc.

### UNIT-I

### UNIT-II

### UNIT-III
Liquid-Liquid Extraction, Ternary Equilibria and its representation on various plots. Selection criteria for solvent, Multistage extraction using partially miscible & immiscible solvents. Stagewise contact for countercurrent and crosscurrent extraction. Constructional details of equipment like mixer-settler, Packed columns, Pulsed extractor, Sieve-tray extractor and centrifugal extractor.

### UNIT-IV
Leaching, Preparation of solid, Countercurrent and crosscurrent contact Shank’s system. Constructional details of equipment like Rotocel extractor, Hildebrandt extractor, Boll-man extractor, Kennedy Extractor & Beet-Sugar Diffusion battery extractor.

Adsorption, Types of adsorption, Nature of adsorbents, Equilibria for adsorption systems. Brief manufacture and commercial applications and characteristics for common adsorbents. Stage-wise &continuous contacting of fluid and solid phase. Description of contact filtration adsorption system. Hypersorber Ion-exchange system.

#### Recommended Books:
- McCabe W L, And Smith J C, Unit Operations of Chemical Engineering, McGraw Hill
- Dutta B K, Mass Transfer and separation process, Prentice Hall of India
- Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE-307  BIOCHEMICAL ENGINEERING

Course Objective:

The aim of this course to understand the basics of biochemical engineering and its industrial applications. After undergoing this course the students will have the knowledge of kinetics of enzyme catalysis, Immobilized enzymes, Metabolic pathways, Biosynthesis, Microbial growth, Analysis and stability of bioreactors and manufacture of biochemical products etc.

UNIT-I

Introduction to Biochemical Engineering, Comparative study of chemical and biochemical processes, Basic concepts of microbiology.

Biochemical Kinetics, Enzyme Kinetics with one or two substrates, Modulation and regulation of enzyme activity, Enzyme reactions in heterogeneous systems, Immobilized enzyme technology, Industrial application of enzymes.

UNIT-II

Microbial Fermentation Kinetics, Fermentation and its classification, Growth-cycle phases (for batch cultivation), Continuous culture, Biomass production in cell culture, Mathematical modeling of batch growth, Product synthesis kinetics, Overall kinetics and thermal death kinetics of cells and spores, Analysis of multiple interacting microbial population.

Bioreactors, Classification and characterization of different bioreactors e.g. Batch and continuous, Mechanically and non-mechanically agitated, CSTR type, Tower, Continuous, Rotating, Anaerobic etc.

UNIT-III

Design and Analysis of Bioreactors- C.S.T.R. and Air Lift Reactor, Scale up considerations of bioprocesses.

Transport Phenomena in Bioprocess Systems, Agitation and aeration-gas-liquid mass transfer, Oxygen transfer rates, Determination of $k_{La}$, Heat balance and heat transfer correlations, Sterilization.

UNIT-IV

Commercial production of bioproducts, Concept of primary and secondary metabolites, Production processes for yeast biomass, Antibiotics, Alcoholic beverages and other products.

Instrumentation and control in bioprocess, Various control parameters for bioprocesses, pH, DO foam/level controller Etc.

Recommended Books:

- Shuler Michael, Kargi Fikret, Bioprocess Engineering: Basic Concepts, Prentice Hall, Englewood Cliffs
- Weith, John W F, Biochemical Engineering – Kinetics, Mass Transport, Reactors and Gene Expression, Wiley and Sons Inc
Course Objective:
The aim of this course is to provide up-to-date knowledge for designing the process equipments generally used in the chemical industries. It emphasizes on providing knowledge about design principles of heat and mass transfer equipment used in chemical plants. It also aims to impart knowledge about IS Codes used in the mechanical design of chemical engineering equipments. After undergoing this course, the students will have the knowledge to analyze a problem and find a design method and mechanical specifications to accomplish a particular process objective.

UNIT-I

UNIT-II
Design of process vessels under internal pressure, Thin wall vessels, Cylindrical vessels, Tubes, Pipes, Spherical vessels, Design of heads and closures such as different heads, Nozzle, Flange joints, Gaskets, Types & design of non-standard flanges and Bolts.

UNIT-III
Design of process vessels under external pressures, Introduction, Determination of safe pressure against elastic failure, Circumferential stiffeners, Spherical shells, Pipes and tubes under external pressure.

UNIT-IV
Design of tall vessels, Introduction, Equivalent stress under combined loadings and Longitudinal stresses.

Design of support for process vessels, Introduction, Different types of supports, Design of supports.

Design of thick walled higher pressure vessels, Introduction, Stresses and theories of elastic failure.

Equipment fabrication and testing, Welding joints, Inspection and Non-destructive testing of equipment.

Design of some special parts, Introduction, Expansion joints and its design, Expansion loop in piping system, Design equations for expansive forces in pipe lines, Shafts and Keys.

Storage tanks, Introduction, Classification of storage tanks, Filling & breathing loose, Design of liquid and gas storage tanks.

Recommended Books:
Course Objective:
The basic principles of these fields are here generalized and reformulated so as to be able to deal with chemically-reacting flow systems of current and future engineering interest. Principles are developed and illustrated here for the rational design of engineering equipment (chemical reactor analysis, Separation processes, Multiphase transport, etc.). Emphasis will be placed on the use of fundamental laws, and a judicious blend of experimental, analytical and numerical methods to develop required understanding and necessary mathematical models for essential portions of engineering problems involving transport processes. After undergoing this course the students will have the knowledge of mechanisms of momentum, energy and mass transport, shell balances and its applications, transport phenomena in polymeric liquids.

UNIT-I
Transport of momentum, Heat and mass by molecular motion-Newton’s law of Viscosity, Fourier’s law of heat conduction, Fick’s law of diffusion.
Transport properties – Viscosity, Thermal conductivity and mass diffusivity.
Emphasis on the analogy between momentum, heat and mass transfer with respect to transport mechanism and governing equations.

UNIT-II
Development of mathematical models of transfer process through shell momentum balance, Shell energy balance and shell mass balance for solving specific problems of transport of momentum, heat and mass in laminar flow or in solids in one dimension.

UNIT-III
Development of general differential equations of fluid flow, Heat transfer and mass transfer and their applications in solving one-dimensional steady state and unsteady state problems of momentum, Heat and mass transfer.

UNIT-IV
Interphase transport of momentum, Heat and mass and dimensionless correlation for each one of them. Momentum, heat and mass transfer analysis.

Recommended Books:
- Bird R B, Stewart W E, And Lightfoot E N, Transport Phenomena, Wiley
- Geankoplis C J, Transport Processes and Unit Operations, Prentice-Hall
- Welty J R, Wicks C E, And Wilson R E, Fundamentals of Momentum, Heat, And Mass Transfer, John Wiley and Sons
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE-313 CHEMICAL REACTION ENGINEERING LAB

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Internal Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 03 Hours

EXPERIMENTS

- Study of non-catalytic homogeneous reaction in a batch reactor.
- Study of non-catalytic homogeneous reaction in a plug flow reactor.
- Residence time distribution (RTD) studied in a packed bed reactor.
- Residence time distribution (RTD) studied in a CSTR.
- Study of non catalytic homogeneous reaction in a series of three CSTR
- To study the performance of a cascade of three equal volume CSTR in series for the saponification of ethyl acetate with NaOH.
- Study of non-catalytic homogeneous reaction in a semi-batch reactor.
- Study of non-catalytic fluid solid reaction in a Muffle furnace.
- To study the series reaction using fluid flow analogy to determine rate constant.
- To study the kinetics of diacetone alcohol decomposition using dilatometer.
- To follow a reaction in a fixed bed catalytic reactor for a given reaction system.
- To study the kinetics of solid phase reaction i.e. calcium carbonate decomposition.
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-315  MASS TRANSFER LAB

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Internal Evaluation: 25 Marks  
External Examination: 25 Marks  
Duration of Examination: 03 Hours

**EXPERIMENTS**

- Vapor-Liquid Equilibrium data - To find out the B.P's of CCl₄-Toluene mixture comprising of different compositions at constant pressure.
- Solid in Air diffusion - To calculate the mass transfer coefficient for vaporization of Naphthalene in air using a packed bed of spherical particles of Naphthalene.
- Vapour in air Diffusion - To determine the diffusion coefficient of an organic vapor, CCl₄ in air and to study the effect of temperature on the diffusion coefficient.
- Liquid-Liquid Extraction of benzoic acid from toluene in a Packed Bed.
  - To determine overall mass transfer coefficient based on continuous phase(water), \( K_{wa} \).
  - To determine overall mass transfer coefficient based on dispersed phase (toluene), \( K_{a} \).
  - To determine overall Height of Transfer Units based on continuous phase (water), \( HTU_{ow} \).
  - To determine individual Height of Transfer Unit based on continuous phase (water), \( HTU_{w} \) and dispersed phase(toluene), \( HTU_{t} \).
- Absorption with chemical reaction in a Packed Bed (CO₂ absorption NaOH solution).
  - Determine the numbers of transfer units, \( NTU \)
  - Determine the height of transfer units, \( HTU \)
  - Plot \( K_{a}(\text{kgmoles}/\text{m}^3\cdot\text{h}\cdot\text{atm}) \) vs mass velocity of liquid, \( L \) (kgmoles/m³-h) on log-log plot for the given packing.
- To find out the critical moisture context of the given material and to find out the equations for constant and falling rate period.
- To verify the Rayleigh's equation for distillation.
- To find the height equivalent to a theoretical plate and height of a transfer unit for the packed distillation column under total reflux.
- Steam Distillation
- To determine gas film coefficient in wetted wall column using air water system.
- To determine the yield of MgSO₄.7H₂O crystals in a Batch Crystallizer.
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING

CHE- 317  BIOCHEMICAL ENGINEERING LAB

Internal Evaluation: 25 Marks
External Examination: 25 Marks
Duration of Examination: 02 Hours

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**EXPERIMENTS**

- To demonstrate the use of rennet in casein coagulation in different pH conditions.
- To determine the concentration of proteins by Lowry's method.
- To demonstrate the presence of microorganisms everywhere in the environment.
- To hydrolyze protein-based stains in fabrics into soluble amino acids.
- To analyze amino acid concentrations by the ninhydrin colorimetric method during the enzymatic hydrolysis of a protein.
- To study the kinetics of alkaline phosphatase.
- Amino Acid Assay by Ninhydrin Colorimetric Method.
- To compare the enzymatic and acid hydrolysis of cellulose.
- To study the various parameters that affects the kinetics of alpha-amylase catalyzed hydrolysis of starch.
- To recover proteins/enzymes from a solution by salting-out
- To recover proteins/enzymes from a solution by adding acetone.
- To compare the effectiveness of three methods of enzyme immobilization by gel entrapment.
- To demonstrate the use of microorganisms in food processing by using yogurt as an example.
- To study the batch growth kinetics of a submerged culture.
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ELGA-301 ENGLISH LANGUAGE AND GENERAL AWARENESS-V

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Course Objective:
To facilitate the learning of the principles of writing effective formal and business letters and also to help them develop an understanding of the infrastructure development initiatives in the country.

UNIT-I

Formal Correspondence
- Parts of a letter
- Format of a formal/business letter
- Formal letters
- Business Letters
- Job application letters (covering letter & resume/CV)

UNIT-II

General Awareness
(a) Infrastructure Development
- Infrastructure and economic development
- Energy
- Power
- Transport
- Roads and highways
- Communication system
(b) Biography: L N Mittal
(c) Book Review: Imagining India by Nandan Nilekani
(d) Industry Overview: Civil Aviation

Recommended Books:
- Mitra Barun K, Effective Technical Communication, Oxford
- Tyagi Kavita & Misra Padma, Basic Technical Communication, PHI
- Raman Meenakshi & Sharma Sangeeta, Professional Communication, Oxford
- Datt & Sundharam, Indian Economy, S Chand
- Sharma R C, Krishna Mohan, Business Correspondence and Report Writing, TMH
Course Objective:
The aim of this course is to give up-to-date knowledge for designing the process equipments such as heat and mass transfer equipments used in chemical plants. After undergoing this course the students will have the knowledge to analyze a problem and finding a process design method for heat and mass transfer equipments used in chemical plants.

UNIT-I
Introduction, Design factors, Equipment selection, General design procedure.
Process design calculations for heat transfer equipment, Shell and Tube heat exchangers-general description, Estimation of heat transfer coefficients and pressure drop by Kerns’ and Bell’s methods.

UNIT-II
Condenser and re-boiler design, Plate type heat exchanger design, Finned tubes, Heat Transfer in stirred vessels, Codes & standards and Heat-exchanger nomenclature, Mechanical turbulators.

UNIT-III
Process design calculations for binary and multi-component distillation, Fenske-Underwood-Gilliland Method, Selection of two key components, Fenske equation for minimum equilibrium stage, Gilliland correlations for actual reflux ratio and theoretical stages, Minimum reflux ratio by Underwood method, Feed stage location,

UNIT-IV
Type of towers, Types of plate contractors, Sieve tray layout and hydraulic design, Packed towers – column internals, Types of packing, General pressure drop correlation, Column diameter and height.
Piping System Design, Piping classification, Important fittings and their use, Symbols, Layouts, And Color codes for pipe lines.

Recommended Books:
- Sinnott Ray and Towler Gavin, Coulson and Richardson’s Chemical Engineering series Chemical Engineering Design
- Seader J D, Henley E J, Separation Process Principles, Wiley
- Bausbacher Ed and Hunt Roger, Process Plant Layout and Piping Design, PTR Prentice Hall
# CHE-304 PROCESS CONTROL AND INSTRUMENTATION

**Course Objective:**

This course Process Control and Instrumentation goes deeper into the various aspects of control engineering along with bringing out the theories and practical knowledge of control engineering. Instrumentation part will consist of valve characteristics, Various measuring devices, Instrumentation symbols and introduction to P&ID. After undergoing this course the students will have the knowledge of dynamic behavior of chemical processes, Stability aspects, Design of feedback controller and control strategies.

<table>
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<tr>
<th>UNIT</th>
<th>Course Content</th>
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<tr>
<td>UNIT-I</td>
<td>Instrumentation, Classification of measuring instruments, Elements of measuring instruments, Static and dynamic characteristics of instruments, Error analysis. Instruments for the measurement of temperature, Pressure, Liquid level, And moisture content, Instruments and sensors for online measurements.</td>
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<tr>
<td>UNIT-II</td>
<td>General Principles of process control, Time domain, Laplace domain and frequency domain dynamic and control. Linear Open loop Systems, Laplace domain analysis of first and second orders systems, Linearization, Response to step, Pulse, Impulse and ramp inputs, Physical examples of first and second order systems such as thermocouple, Level tank, U-tube manometer etc., Interacting and non-interacting systems distributed and lumped parameter systems, Dead time.</td>
</tr>
<tr>
<td>UNIT-III</td>
<td>Linear Closed-loop Systems, Controllers and final control elements, Different types of control valves and their characteristics, Development of block diagram, Transient response of simple control systems, Stability in Laplace domain, Root locus analysis. Frequency Response, Frequency domain analysis, Control system design by frequency response, Bode stability criterion, Different methods of tuning of controllers.</td>
</tr>
<tr>
<td>UNIT-IV</td>
<td>Process Applications, Introduction to advanced control techniques as feed forward, Feedback, Cascade, Ratio, Smith predictor, Internal model control, Digital computer control, Direct digital control and supervisory control and data acquisition, Multivariable control, Applications to equipments such as heat exchangers, Distillation columns, Reactors etc.</td>
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</table>

**Recommended Books:**

- Stephanopoulous G, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall of India
- Eckman D P, Industrial instrumentation, John Wiley & Sons
Course Objective:

After passing the course the student shall be able to show deeper knowledge about different forms of energy and transferring from one energy form to another show knowledge and understanding about different methods for use of renewable energy and the technology in practice show ability to assess, Analyze, And integrate knowledge about different forms of renewable energy and their suitability in environments with different conditions.

UNIT-I

- Energy Scenario, Indian and global, Energy crisis, Classification of various energy sources, Renewable and Non-renewable energy sources, Pattern of energy consumption, Present and future energy demands.
- Solid Fuels, Coal its origin and formation, Coal analysis, Coal classification, Coal preparation, Coal washing and coal blending, Coal carbonization, Treatment of coal gas and Recovery of chemicals from coal tar, Coal gasification, Liquid fuel synthesis from coal, Carbonization of coal, Briquetting of fines, Bio Mass.

UNIT-II

- Liquid and Gaseous Fuels, Crude petroleum, Physical processing of crude petroleum, Fuels from petroleum, Storage and handling of liquid fuels, Natural gas and Liquefied Petroleum gases, Gas hydrates, Gasification of liquid fuels, Carbureted water gas, Bio gas.

UNIT-III

- Fuel Characterization, Viscosity, Viscosity index, Flash Point, Cloud point, Pour point, Fire point, Smoke point and Char value, Carbon residue, Octane number, Cetane number, Aniline Point and Performance number, Acid value, ASTM distillation, Calorific value, Proximate and ultimate analysis.

UNIT-IV

- Energy Conversion without Combustion, Solar energy, Radiation measurement, Applications and types of collectors and storage, Wind power, Principle of energy from wind applications, Geothermal energy, Biomass, Biogas and Thermal gasification, Nuclear power, Fuel cells.

Recommended Books:

- Gupta O P, Elements of Fuel, Furnaces and Refractories, Khanna Publishers
- Rai G D, Non-Conventional Energy Sources, Khanna Publishers
- Brame J S S and King J G, Edward Arnold, Fuel Solid, Liquid and Gases
Course Objective:
The Process Modeling and Simulation of Chemical engineering processes has attracted the attention of scientists and engineers for many decades and is still a subject of major importance for the knowledge of unitary processes of transport and kinetics. After undergoing this course the students will have the knowledge of models development for heat transfer equipments, Separation processes and reactors, Parameter estimations, Application of numerical methods for solution of models and tools of simulation.

UNIT-I
Introduction, Use and scope of mathematical modeling, Principles of model formulation, Role and importance of steady-state and dynamic simulation, Classification of models, Model building, Modeling difficulties, Degree-of-freedom analysis, Selection of design variables, Types of equations.

UNIT-II
Fundamental Laws, Equations of continuity, Energy, Momentum, Transport, And state, Transport properties, Equilibrium and chemical kinetics, Review of thermodynamic correlations for the estimation of physical properties like phase equilibria, Bubble and dew points etc, Prediction of enthalpy departure and VLE characteristics from equation of state by the application of numerical methods.

UNIT-III
Modeling of Specific Systems, Constant and variable holdup CSTRs under isothermal and non-isothermal conditions, Stability analysis, Gas phase pressurized CSTR, Two phase CSTR, Non-isothermal PFR, Batch and semi-batch reactors, Heat conduction in a bar, Laminar flow of Newtonian liquid in a pipe, Gravity flow tank, Single component vaporizer, Multi-component flash drum, Absorption column, Ideal binary distillation column and non-ideal multi-component distillation column, Batch distillation with holdup etc.

UNIT-IV
Simulation, Simulation of the models, Sequential modular approach, Equation oriented approach, Partitioning and tearing, Introduction and use of process simulation software (ASPEN/Hysis) for flow sheet simulation.

Recommended Books:
- Luyben W L, Process Modeling, Simulation, And Control for Chemical Engineering, McGraw-Hill
- Babu B V, Process Plant Simulation, Oxford University Press
- Denn M M, Process Modeling, Longman Sc & Tech
**Course Objective:**

This is a typical second course in the subject of chemical reaction engineering with an emphasis on heterogeneous reaction engineering and nonideal reactors. After undergoing this course the students will have the knowledge of Kinetics and design of reactors for noncatalytic gas-liquid and fluid-solid reactions, Residence time distributions.

<table>
<thead>
<tr>
<th>UNIT-I</th>
<th>Non-ideal Flow, Residence time distribution of fluids in vessels, Models for non-ideal flow- one and two parameter, Conversion calculation using RTD data for first order reactions.</th>
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<tr>
<td>UNIT-II</td>
<td>Non-catalytic Heterogeneous Reactions, Fluid-Solid reaction kinetics, Fluid-solid reaction models, Determination of rate controlling step, Prediction of mean conversion in flow reactors, Fluid-solid contacting schemes, Reactor design.</td>
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<tr>
<td>UNIT-III</td>
<td>Solid-catalyzed Reactions, Interaction of physical and chemical rate processes, Kinetics of catalytic reactions and application to reactor design for isothermal and adiabatic operations, Experimental reactors, Design of fixed and fluidized bed reactors, Introduction to slurry and trickle-bed reactors.</td>
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<tr>
<td>UNIT-IV</td>
<td>Fluid-fluid Reactions, Introduction to fluid-fluid reaction systems, Rate equations, Reactor design for straight mass transfer and for mass transfer with chemical reaction.</td>
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**Recommended Books:**

- Levenspiel O, Chemical Reaction Engineering, John Wiley & Sons
- Fogler H S, Elements of Chemical Reaction Engineering, Prentice Hall of India
- Smith J M, Chemical Engineering Kinetics, McGraw Hill
- Nauman E B, Chemical Reactor Design, John Wiley & Sons
**Course Objective:**

In many UG curriculums, Elementary process design is taught without relevance to economics. However, Economics and cost invariably affect the design aspects of several chemical processes and optimization is often regarded as a key issue in due course of design. After undergoing this course the students will have the knowledge of cost estimation of chemical process plant, Taxes and insurance, Depreciation etc.

**UNIT-I**


**UNIT-II**

Interest and Investment Costs, Simple and compound interest. Nominal and effective rates of interest. Continuous interest ordinary annuity. Perpetuities and capitalized costs.

Taxes and Insurance, Types of taxes and tax returns, Types of insurance and legal responsibility.

Depreciation, Types of depreciation, Service life salvage value, Present value and methods of determining depreciation, Single unit and group depreciation.

**UNIT-III**


**UNIT-IV**

Optimum Design, Procedure with one variable, Optimum reflux ratio in distillation and other examples.

Preliminary Steps in Plant Design, Plant design factors, Project organization, Plant location, Preliminary data collection, Process engineering

**Recommended Books:**

- Peters M A and Timmerhaus K D, Plant Design and Economics for Chemical Engineers, McGraw Hill
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE- 314 PROCESS CONTROL AND INSTRUMENTATION LAB

EXPERIMENTS

- To measure the pressure by using pressure transducer.
- Calibration of a thermocouple by using mercury thermometer.
- To determine the kinematic viscosity of given sample.
- Characteristics of on-off controller.
- Dynamic response of single tank system.
- Dynamics of a two tank non-interacting liquid level system.
- Dynamics of a two tank interacting liquid level system
- Response of CSTR heater system.
- Characteristics of PID controller.
- To obtain the time constant of a thermometer
- Valve characteristics
- Flow, Level and temperature control using proportional, Proportional-integral and proportional-integral-derivative control action.
- Tuning of controller
## B TECH: CHEMICAL ENGINEERING
## M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
### CHE-316  ENERGY TECHNOLOGY LAB

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**Internal Evaluation: 25 Marks**  
**External Examination: 25 Marks**  
**Duration of Examination: 03 Hours**

### EXPERIMENTS

- To determine moisture volatile and ash contents in a given coal sample by proximate analysis.
- To determine the flash point and fire point of given oil by Pensky-Martens flash point apparatus.
- To determine the flash point and fire point of a given oil by Abel’s flash point apparatus.
- To determine cloud and pour point of a lubricating oil.
- Determination of viscosity of the given lubricating oils using Redwood viscometer.
- To determine the surface tension of the provided liquid sample.
- Determination of viscosity of the given lubricating oils using Saybolt viscometer.
- To determine the calorific value of the given fuel using calorimeter.
- To determine the specific gravity of a given liquid sample using specific gravity balances.
- To determine the Reid vapour pressure of the gasoline sample.
- To determine saponification value of a given oil sample.
- To determine acid value of a given oil sample.
- To perform the ASTM distillation of the fuel sample.
### CHE-318 PROCESS MODELING & SIMULATION LAB

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**Internal Evaluation:** 25 Marks  
**External Examination:** 25 Marks  
**Duration of Examination:** 03 Hours

**EXPERIMENTS**

- Develop a computer programme for the solution of multivariable non linear algebraic equations.
- Develop a computer programme for the solution of multivariable ordinary differential equations.
- Develop a computer programme for the solution of second order ordinary differential equations.
- Modeling and Simulation of bubble point temperature.
- Modeling and Simulation of dew point temperature.
- Modeling and Simulation of T-xy and P-xy of a binary mixture.
- Modeling and Simulation of isothermal CSTR
- Modeling and Simulation of non- isothermal CSTR
- Modeling and Simulation of isothermal batch reactor
- Modeling and Simulation of non - isothermal batch reactor
- Modeling and Simulation of isothermal of distillation column.
- Simulation of chemical engineering systems by the use of available software (Aspen Plus, Aspen Hysis or CHEMCAD etc.)
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-320   UG SEMINAR  

Internal Evaluation: 50 Marks

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**SEMINAR**  
The student is required to deliver an independent seminar on any of emerging areas/ application of Chemical Engineering courses. Senior faculty will supervise the students in selecting and preparation of the same. The student will submit two copies of seminar report (at least one week prior to the presentation) and shall make oral presentation as per time schedule decided by the faculty concerned. Internal Evaluation will be made on the basis of report, presentation and the discussion during the presentation.
Course Objective:
To help the students understand the nuances of technical writing that would enable them to communicate effectively and efficiently at their workplace, And, Through the General Awareness section, An overview of economic planning in India.

UNIT-I
Technical Writing
- Guidelines for technical writing
- Effective use of charts, Graphs, Tables etc.
- Technical reports
  - Types of reports
  - Steps in writing a report
  - Guidelines for writing a report

UNIT-II
General Awareness
(a) Economic Planning in India
- Objectives of economic planning in India
- Review of 60 years of planning in India
- 11th Plan (2007-12): achievements and failures
- 12th Plan (2012-17): objectives, Targets & strategy
(b) Biography: Bill Gates
(c) Book Review: A Better India; A Better World by N R Narayana Murthy
(d) Industry Overview: Renewable Energy

Recommended Books:
- Barun K Mitra, Effective Technical Communication, Oxford
- Tyagi Kavita & Misra Padma, Basic Technical Communication, PHI
- Raman Meenakshi & Sharma Sangeeta, Technical Communication, Oxford
- Datt & Sundharam, Indian Economy, S Chand
- Sharma R C, Krishna Mohan, Business Correspondence and Report Writing, TMH
### B TECH: CHEMICAL ENGINEERING
### M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING

#### CHE-411  INDUSTRIAL TRAINING/PROJECT

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**Internal Evaluation:** 200 Marks  
**External Examination:** 200 Marks

**INDUSTRIAL TRAINING/PROJECT**

Each student is expected to undergo one complete semester of industrial/field/Lab training (UG level) in order to connect the class room teaching with real time practical applications. A supervisor (faculty from the Department) shall be assigned to the student approved by the competent authority. The training and placement officer (TPO) will facilitate the students for the purpose with the consent of his/her supervisor and also considering the interests of the student. During training the student will undertake a project involving design/experimental/analytical/computational work including case studies etc. The progress of the project work will be evaluated by the concerned supervisor and TPO by visiting the site/industry/lab etc.

The student will complete the training/project by the end of the semester and a comprehensive training/project report will be submitted by the student under the signature of his/her supervisor. The external examination shall be taken by a panel of examiners comprising of concerned supervisor, The training and placement officer and an external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of report are required to be submitted by the student before the external examination. The candidate shall appear before the evaluation committee for oral examination and presentation on the scheduled date.
Course Objective:
Petroleum and petrochemical industries are the most prolific and dynamic industries. The main objective of this course is to provide students a thorough understanding in the area of crude oil refining, Hydrocarbon processing and trends in refinery operations which is the current need of the country. The physical and chemical properties of petroleum and petroleum products will be described, Along with major refining processes.

UNIT-I
Introduction, World petroleum resources, Petroleum industry in India, Origin, Exploration, Drilling and production of petroleum crude, Transportation and pretreatment of crude oil.

UNIT-II
Characterization, Composition and classification of petroleum crude, ASTM, TBP and EFV distillation of crude oil, Properties and specifications of petroleum products - LPG, Gasoline, Naphtha, Kerosene, Diesel oil, Lubricating oil, Wax etc.

UNIT-III
Separation Processes, Pretreatment of crude, Crude distillation, Vacuum distillation, Gasoline treatment and operation of topping, Tube still furnaces, Solvent extraction processes for lubricating oil base stocks and for aromatics from naphtha and kerosene, Dewaxing.

UNIT-IV
Conversion Processes, Thermal and catalytic cracking, Vis-breaking and coking processes, Reforming, Hydroprocessing, Alkylation, Polymerisation and isomerisation, Product finishing processes.

Recommended Books:
- Gary J H and Handwerk G E, Petroleum Refining, Technology, And Economics, Marcel Dekker
- Sarkar G N, Advanced Petroleum Refining, Khanna Publishers
Course Objective:

The aim of this course is to give basic concept in fluidization engineering and its application in industry. After undergoing this course the students will have the knowledge of flow around immersed solids, Sedimentation and packed bed pressure drop, Minimum fluidization velocity, Fluidization regimes, Homogeneous fluidized beds, Turbulent and fast fluidization, Heat and mass transfer in fluidized beds, CFD and flow visualization techniques, Three phase fluidization.

UNIT-I

Fluidization phenomenon, Review of flow around immersed solids - forces on single particles, sedimentation - Richardson-Zaki equation, Packed beds and Ergun equation, Classification of solid particles and powders - relevant properties and measurements, Effect of fluid velocity on pressure gradient, Minimum fluidization velocity - measurement, Prediction and correlations, Regimes of fluidization - Homogenous fluidized bed models.

UNIT-II

Stability of homogeneous fluidization - qualitative and quantitative, Kinematic and dynamic wave propagation, Bubbling bed (heterogeneous fluidized bed) models, Davidson model for bubble in a fluidized bed, And its implications.

UNIT-III

Turbulent and fast fluidization, Entrainment and Elutriation, Slugging, Spouted beds, Dilute and dense phase transport - Circulating Fluidized Beds.

UNIT-IV

Heat and mass transfer in fluidized systems, Pneumatic conveying of solids in vertical and horizontal conduits, Hydraulic conveying of solids in vertical and horizontal conduits, Modern simulation techniques - CFD models, Modern experimental techniques - flow visualization and quantitative measurements, Three-phase fluidization.

Recommended Books:

- Kunii D, Levenspiel O and Robert E, Fluidization Engineering, Butterworth-Heinemann
- Rhodes M, Introduction to Particle Technology, 2nd Ed., Wiley
- Gibilaro L G, Fluidization - Dynamics, Butterworth - Heinemann
# B TECH: CHEMICAL ENGINEERING  
# M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
# CHE-421/422/423/424  COMPUTATIONAL FLUID DYNAMICS

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**Course Objective:**

The aim of this course is to provide an in-depth introduction to the methods and analysis techniques used in computational solutions of fluid mechanics and heat transfer problems. Model problems are used to study the interaction of physical processes and numerical techniques. Contemporary methods for boundary layers, Incompressible viscous flows, And inviscid compressible flows are studied. After undergoing this course the students will have the knowledge of modeling approaches for multiphase flow, Discretization of the governing equations using finite difference/volume/element methods, Concepts of consistency, Stability and convergence, Solution of discretized equations and coupled equations and structured and unstructured grids generation.

**UNIT-I**

Importance and applications of computational fluid dynamics in engineering, Illustration of the CFD approach, CFD as an engineering analysis tool, Derivation of flow governing equations, Turbulence modeling, Modeling approaches for multiphase flow, Initial and boundary conditions, Wellposedness.

**UNIT-II**

Turbulence modeling, Discretization of the governing equations using finite difference/volume/element methods, Concepts of consistency, Stability and convergence; template for the discretization of a generic unsteady transport equation.

**UNIT-III**

Spectral analysis of errors and TVD schemes. Solution of discretized equations; direct methods; classical iterative methods; advanced methods for structured matrices; conjugate gradient techniques; multigrid methods. Solution of coupled equations, methods for compressible flows; evaluation of pressure in incompressible flows; pressure-velocity coupling algorithms.

**UNIT-IV**


**Recommended Books:**

- Muralidhar K and Sundararajan T, Computational Fluid Flow and Heat Transfer, Narosa Publishing House
- Ferziger J H and Peric M, Computational Methods for Fluid Dynamics, Springer
Course Objective:

The aim of this course is to provide students a thorough understanding in the area of polymer science and technology and its application. After undergoing this course the students will have the knowledge of basic concepts of polymer science, Polymer Properties and synthesis, Polymer Processing and different types of polymer composites.

UNIT-I
Basic concepts of polymer science, Classification of polymers, Molecular architecture and molecular weight distribution, Thermal characteristics, Rheological characteristics, Properties and Additives.

UNIT-II
Introduction to polymer Synthesis, Addition polymerization, Condensation polymerization, Modification of Preformed Polymers, Commercial Production Technology of common polymers including Polyethylene, Polypropylene, Nylon, Polyethylene terephthalate.

UNIT-III
Introduction to polymer Processing, Chemical engineering fundamentals for polymer processing, Extrusion, Injection molding, Other processes such as calendaring, Film Blowing, Thermoforming.

UNIT-IV
Polymer Blends, Compatibility, Types, Properties, Glass transition temperature. Polymer Composites, Types, Properties, Preparation. Polymer Nanocomposites, Basic concepts, Preparation, Characterization.

Recommended Books:
- Billmeyer F W Jr, Text Book of Polymer Science, Wiley & Sons
- Tadmo Z, Gogos C G, Principles of polymer processing, Wiley Interscience
- Polymer Processing: Principles and Modelling, By Agassant, Avenas, Sergent, Carreau
- Crawford R J, Plastics Engineering
- Odian George, Principles of Polymerization
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING

CHE-421/422/423/424 SCALE-UP AND PILOT PLANT METHODS IN CHEMICAL ENGINEERING

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Internal Evaluation: 50 Marks
External Examination: 50 Marks
Duration of Examination: 03 Hours

Course Objective:
This course will provide concepts, Methods and advice on how to scale-up or translate a process or model to larger sizes. Emphasis throughout the course will be on proper designs, Modeling and processing. The importance of the process geometry will be emphasized. The course will cover the different scale-up methods and how to establish viable process objectives.

UNIT-I
Scale up, Description and evolution of a process system, Introduction to Scale up procedures, Dimensional analysis, Similitude.
Reactors for Fluid Phase Processes Catalyzed by Solids, Pseudo-homogeneous and heterogeneous models, Two-dimensional models, Scale up considerations.

UNIT-II
Fluid-fluid Reactors, Scale-up considerations in packed bed absorbers and bubble columns, Applicability of models to scale-up.
Mixing Processes, Scale-up relationships, Scale-up of polymerization units, Continuous stages gas-liquid slurry processes, Liquid-liquid emulsions

UNIT-III
Fluidized Beds, Major scale-up issues, Prediction of performance in large equipment, Practical commercial experience, Problem areas.
Solid-Liquid Separation Processes, Fundamental considerations, Small scale studies for equipment design and selection, Scale-up techniques, Uncertainties.

UNIT-IV
Continuous Mass Transfer Process, Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units.

Recommended Books:
- Bisio A and Kabel R L, Scale-up of Chemical Processes, John Wiley
- Johnstone R E and Thring M W, Pilot Plants, Models and Scale-up Methods in Chemical Engineering, McGraw-Hill
Course Objective:
This course will help students to understand proper usage of water for drinking purpose - from identification of source, Planning the treatment systems, Distribution of treated water with development of distribution of layout and necessity of maintenance.

UNIT-I
Water supply Engineering: Importance and necessity of community water supply schemes, Essentials of water supply engineering, Quantity of water, Forecasting population, Rate of consumption for various purposes, Factors affecting consumption, Fluctuations in demand.

UNIT-II
Sources of water, Surface water sources, Suitability of the source with respect to quantity and quality, Intakes of various surface water sources, Design of intakes, Ground water sources, Development and protection of groundwater sources, Estimation of yield from various ground water sources, Construction of tube wells, Maintenance. Quality of water, Drinking water standards, Physical, Chemical and bacteriological analysis of water.

UNIT-III
Treatment of water- aeration, Coagulation, Flocculation, Sedimentation, Design of sedimentation tanks, Filtration- slow and rapid filter design, Disinfection, Design of all the units of water treatment plant, Miscellaneous treatments- removal of colour, Taste and odor, Iron and manganese, And hardness, Fluoridation and defluoridation.

UNIT-IV
Water supply schemes, Gravitational, Pumping and combined schemes, Transmission of water, Classification of conduits, Shape and strength of conduits, Location of conduits, Materials of conduits, Design of gravity and pumping main, Distribution systems, Different layout of pipe networks, Analysis of pipe networks, House connection from mains, Laying and joining of pipes, Appurtenances, Different valves, Meters and hydrants, Detection and prevention of leaks in distribution system, Cleaning and maintenance of distribution system.

Recommended Books:
- Duggal K N, Elements of Environmental Engineering, S Chand & Co Ltd, 2008
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
CHE-421/422/423/424 PROCESS OPTIMIZATION

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Course Objective:

In "Process Optimization" the various aspects of traditional process optimization and newer developments like genetic algorithms and mixed integer optimization and their applications in process engineering will be covered. Each topic will be developed in a logical progression with up-to-date information with references from open literature. The topics will cover basics of optimization, Establishing conditions for finding the stationary point under different conditions, Traditional line search techniques, Unconstrained and constrained optimization, Direct and indirect methods, Genetic algorithms and multi-objective optimization, Mixed integer optimization.

UNIT-I

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 Scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of unidimensional search, Region elimination methods, How to apply one dimensional search in a multidimensional problem.

UNIT-II

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 gradient method.

Indirect methods (second order), Newton's method, Forcing the Hessian matrix to be positive definite, Relation between conjugate gradient methods and Quasi-Newton method.

UNIT-III

Linear programming and applications, Basic concepts in linear programming, The simplex method of solving linear programming problems, Standard LP form, Obtaining a first feasible solution, LP applications.

UNIT-IV

Nonlinear programming with constraints, The Lagrange multiplier method, Necessary and sufficient conditions for a local minimum, Quadratic programming, Generalized reduced-gradient method, Penalty function and augmented Lagrangian methods. Successive quadratic programming, NLP applications.

Recommended Books:

- Deb K, Optimization for engineering design: Algorithms and examples, Prentice Hall of India, New Delhi
Course Objective:

This course will help students to learn how to derive and apply the energy and material balances that are required to design isothermal and non-isothermal batch, Plug flow and continuous stirred tank reactors. They will also learn how to approach and solve variable density and multiple independent reaction problems. The course presents the fundamentals of reaction Stiochiometry, Reaction analysis, and simple kinetic analysis of homogeneous and heterogeneously catalyzed reactions. The course addresses mixing and covers simple, One-parameter non-ideal reactor models.

UNIT-I

- Multiple Reactions, Maximizing desired product in parallel reactions and series reactions, Algorithm for solution to complex reactions.

UNIT-II

- Steady State Non-isothermal Reactor Design, Combining material and energy balances for non-isothermal CSTR and Plug flow reactors (adiabatic and with heat exchange), Adiabatic temperature and equilibrium conversion, Optimum feed temperature, Multiple steady states, Non-isothermal multiple reactions.

UNIT-III

- Gas-Solid Reactions, Shrinking core model, Determination of rate controlling step and corresponding rate law, Prediction of mean conversion in flow reactors, Design of reactors for gas-solid reactions.
- Solid Catalyzed Reactions, Diffusion and reaction in spherical catalyst pellets, Estimation of diffusion and reaction limited regimes, Mass transfer and reaction in a packed bed, Multiphase reactors, Fluidized bed reactors.

UNIT-IV

- Non-ideal Reactors, Measurement of RTD, Characteristics of RTD, RTD in ideal reactors, Reactor modeling using RTD, One and two parameter models for non-ideal reactors.

Recommended Books:

- Fogler H S, Elements of Chemical Reaction Engineering, Prentice-Hall India
- Levenspiel O, Chemical Reaction Engineering, John Wiley
- Smith J M, Chemical Engineering Kinetics, McGraw-Hill
Course Objective:

Process integration, a part of Process Intensification, is a fairly new term that emerged in the 80's and has been extensively used in the 90's to describe certain systems-oriented activities related primarily to process design. Process Integration has evolved from a heat recovery methodology in the 80's to become what a number of leading industrial companies in the 90's regarded as a "major strategic design and planning technology". This course will help understanding students different ways to significantly reduce the operating cost of existing plants, while new processes often can be designed with reduction in both investment cost and operating cost.

UNIT-I

Introduction to process Intensification and Process Integration (PI), Areas of application and techniques available for PI, Onion diagram.

Pinch Technology—an overview, Introduction, Basic concepts, How it is different from energy auditing, Roles of thermodynamic laws, Problems addressed by Pinch Technology, Key steps of Pinch Technology like Concept of $\Delta T$, Data Extraction, Targeting, Designing, Optimization—Super targeting, Basic Elements of Pinch Technology, Grid Diagram, Composite curve, Problem Table Algorithm, Grand Composite Curve.

UNIT-II

Targeting of Heat Exchanger Network, Energy Targeting, Area Targeting, Number of units targeting, Shell Targeting and Cost targeting.

Designing of HEN, Pinch Design Methods, Heuristic rules, Stream splitting, Design of maximum energy recovery (MER), Use of multiple utilities and concept of utility pinches, Design for multiple utilities pinches, Concept of threshold problems and design strategy, Network evolution and evaluation—identification of loops and paths, Loop breaking and path relaxation.

UNIT-III

Design tools to achieve targets, Driving force plot, Remaining problem analysis, Diverse pinch concepts, MCP ratio heuristics, Targeting and designing of HENs with different $\Delta$ Tmin values, Variation of cost of utility, Fixed cost, TAC, Number of shells and total area with $\Delta$ Tmin Capital-Energy trade-offs, Process modifications—Plus/Minus principles, Heat Engines and appropriate placement of heat engines relative to pinch. Heat pumps, Appropriate placement of heat pumps relative to pinch.

UNIT-IV

Steam Rankin Cycle design, Gas turbine cycle design, Integration of Steam and Gas turbine with process. Refrigeration systems, Stand alone and integrated evaporators. Heat integrations and proper placement of Reactors for batch Processes as well as continuous processes, Retrofit of distillation systems, Case studies.

Recommended Books:

Course Objective:
This course aims to introduce to students of final year Chemical Engineering disciplines, The Indian Nuclear programme, The types of nuclear reactors, Principle of heat generation, Heat removal & control in thermal reactors, Concept of breeding, Fast breeder neutronics, Core configuration & heat removal in fast breeder reactors.

UNIT-I
Introduction to reactor system & Three stage Indian nuclear power programme. Classification of reactors, Characteristics of research, Test & power reactors with examples, Core configuration & cycle diagrams of thermal reactors (BWR, PWR, PHWR, AGR, HTGR, AHWR) and Fast Reactors, Reactors – Characteristics, Selection criteria and comparison of different core and structural materials for reactor internals.

UNIT-II

UNIT-III
Secondary systems, Description of flow sheet and major components, Comparison of operating conditions, thermal cycles and major components of thermal and nuclear units Typical reactivity balance, Reactor control system – requirements of physics aspects, Reactor shut down mechanisms. FBR neutronics, Neutron spectrum, Reaction cross-section, Core characteristics, Blanket characteristics, Breeding potential, Breeding ratio, Breeding gain and doubling time. Fast Breeder Reactors, Breeding, Breeders as inexhaustible energy source.

UNIT-IV
Characteristics and types of fast reactors, Comparison of some characteristics of fast and thermal reactors, Role of fast reactors in Indian nuclear power programme. General features of fast reactor core, Introduction, Specific power, Power density, Linear heat rating, Burnup, Fluence, Operating condition, Requirement and choice of core materials, Fuel, Absorber, Coolant & structural materials. Core engineering, Design constraints - linear rating, Maximum temperature of clad, Coolant velocity, Outlet temperature of coolant, Pressure drop in core, Core height/diameter ratio, Blanket thickness, Shielding thickness Heat transport system, Introduction to sodium technology – Properties, Characteristics and complexities. Heat transport circuit system components

Recommended Books:
Course Objective:
The aim of this course to give exposure to the basic aspects of energy management, Creating awareness of energy saving methods & practices. The course discusses various techniques of energy management applicable to buildings as well as industrial applications. Further, This course has been well organized to facilitate in-depth learning of alternate sources of energy and audit to supplement the conservation techniques in demand side management.

UNIT-I
Introduction, Energy scenario - supply and demand, Energy intensive industries, Industrial use of energy, Importance of energy in industrial promotion and employment. Energy Audit, Importance of energy audit and questionnaire, Instruments used in energy audit.

UNIT-II
Identification of quality and cost of various energy inputs, Evaluation of energy consumption pattern in different processes, Heat loss analysis, Electrical energy input analysis.

UNIT-III
Energy Conservation, Analysis of scope and potential for energy conservation, Good housekeeping practice, Energy storage such as thermal insulation, Accumulators and storage media, Co-generation practice, Efficiency improvement in boilers, Furnaces etc. and heat recovery techniques, Energy saving aspects of environment, Electrical energy conservation by using variable speed drives and motor controllers, Analysis of pumps, Process integration as a measure of energy conservation.

UNIT-IV
Water Management, Sources of water, Importance of water in industrial applications, Flow monitoring devices, Quality and cost of water, Water distribution in process industries and scope for water conservation, Analysis of effluents, Treatment and recycle of water.

Recommended Books:
- Reay D A, Industrial Energy Conservation, Pergamon Press
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
CHE-421/422/423/424 WASTE WATER TREATMENT

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Course Objective:
To expose students to the area of waste treatment - with emphasis on domestic liquid wastes - its characterization, Collection, Treatment and disposal at individual household level to community level (rural and urban). To impart the basic concepts of solid waste management and air pollution control.

UNIT-I
Quality parameters of sewage, BOD, COD, Solids, D.O., Oil & Grease. Indian Standards for disposal of effluents into inland surface sources and on land.

UNIT-II

UNIT-III

UNIT-IV
Sludge treatment and disposal- quantity of sludge, Characteristics of sludge, Sludge thickening, Digestion, Conditioning and disposal, Design of sludge digesters only. Septic Tanks: Design (as per Ministry of urban development) construction, Disposal of effluents, Cleaning of tanks, Imhoff tanks. Sewage treatment by high rate anaerobic methods: Anaerobic digestion suspended growth, Contact process, UASB, Attached growth, Filters, Expanded bed, Only basics.

Recommended Books:
- Garg S K, Sewage Disposal and Air Pollution, Khanna Publishers, New Delhi, 1996
**Course Objective:**

To allow students to understand the basic concepts of environmental chemistry and basics of microbiology.

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<td>UNIT-IV</td>
<td>Culturing of microorganisms-Environmental factors influencing microbial growth Distribution of microorganisms-Water, Air and Soil, Indicator organisms, Coliforms-fecal coliforms, E. coli, Streptococcus, Clostridium, Significance in water. Algae in water supplies-problems and control. MPN and MFT. Ecotoxicology-toxicants and toxicity, Factors influencing toxicity, Effects-acute, Chronic, Concentration response relationships, Test organisms, Toxicity testing, Bio concentration, Bioaccumulation, Bio magnification, Bioassay, Bio monitoring.</td>
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**Recommended Books:**

- Vanloon G W and Duffy S J, Environmental chemistry - a global perspective, Oxford University press, New York
- Pelczar M J, Chan E C S and Krieg N R, Microbiology, Tata Mcgraw Hill, New Delhi
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ESE-614  WATER TREATMENT PROCESSES

Course Objective:
This course will make students to understand advanced methods of water treatment processes.

UNIT-I

UNIT-II
Mixing, Clarification-Sedimentation; Types; Aeration and gas transfer - Coagulation and flocculation, Coagulation processes - stability of colloids - destabilization of colloids transport of colloidal particles, Clariflocculation.

UNIT-III
Filtration - theory of granular media filtration; Classification of filters; slow sand filter and rapid sand filter; mechanism of filtration; modes of operation and operational problems; negative head and air binding; dual and multimedia filtration, Design.

UNIT-IV

Recommended Books:
- Manual on Water Supply and Treatment, CPHEEO, GOI, N Delhi
- Weber W J, Physicochemical Processes for Water Quality Control, Wiley Interscience, NY
- Sincero A P and Sincero G A, Environmental Engineering, PHI, New Delhi
- Metcalf and Eddy, Wastewater Engineering, Treatment and Reuse, Tata McGraw-Hill, New Delhi
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING

ESE-616 ENVIRONMENTAL ENGINEERING LAB-I

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EXPERIMENTS

- To determine the pH of a given sample of water.
- To determine the various forms of alkalinity and acidity in water sample.
- To determine the chloride content in a given water sample.
- To determine temporary and permanent hardness in a given sample of water.
- To determine total, dissolved, suspended and volatile residues in water sample.
- To determine the dose of coagulant required for optimum coagulation.
- To determine the dissolved oxygen (DO) in a given sample of water.
- To determine the sulphate concentration in a given sample of water.
- To determine the coliform bacteria by total count method in a given sample of water.
- To determine the most probable number of coliform bacteria in a given water sample by British technique.

Recommended Books and Codes:

- Standard Methods for the Examination of Water and Wastewater, APHA Washington DC.
- IS: 3025, Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater
- IS: 2720, Method of Test for Soils
### B TECH: CHEMICAL ENGINEERING
### M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
### ESE-618  PG SEMINAR

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**Internal Evaluation: 50 Marks**

| SEMINAR | Each one of the students will be assigned to work on a Seminar Topic in the current and advanced areas of environmental science & engineering, including application of other engineering disciplines in civil engineering. The student has to conduct a detailed literature review on the assigned topic and prepare a report. The student will make an oral presentation followed by a brief question and answer session. The Seminar (including presentation and report) will be evaluated by the faculty members assigned for this purpose. |
**Course Objective:**

**UNIT-I**

**UNIT-II**

**UNIT-III**

**UNIT-IV**

**Recommended Books:**
- Beeby A and Brennan A N, First Ecology, Oxford University Press
- Deswal S and Deswal A, A Basic Course in Environmental Studies, Dhanpat Rai & Co. (P) Ltd., N Delhi
- Sharma P D, Ecology and Environment, Ashish Publication
- Bharucha E, The Biodiversity of India, Mabin Publishing, Ahmedabad
**B TECH: CHEMICAL ENGINEERING**  
**M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING**  

**ESE-623  AIR AND NOISE POLLUTION**

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**Course Objective:**

- **UNIT-I**

- **UNIT-II**
  - Meteorological aspects of air pollution: dispersion of air pollutants, Plume behaviours, Air diffusion models, Design of stacks, Effects of air pollution on meteorological conditions.

- **UNIT-III**
  - Air pollution sampling: ambient and stack sampling, Ambient air quality monitoring, Air quality standards. Engineered methods of air pollution control: atmospheric cleansing processes, Approaches to contaminant control, Control devices for particulate contaminants and gaseous contaminants.

- **UNIT-IV**
  - Definition, Unit of measurement, Loudness, Hearing mechanism, Measurement of noise and weighting networks, Sources of noise, Psychological & pathological effects of noise, Strategies for noise pollution control, Noise monitoring and standards.

**Recommended Books:**

- Deswal S and Deswal A, A Basic Course in Environmental Studies, Dhanpat Rai & Co. (P) Ltd. N Delhi
- Sincero A P and Sincero G A, Environmental Engineering, PHI, N Delhi
**Course Objective:**

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<td>UNIT-IV</td>
<td>Anaerobic processes-Process fundamentals-Standard, High rate and hybrid reactors, Anaerobic filters-Expanded /fluidized bed reactors- Upflow anaerobic sludge blanket reactors, Expanded granular bed reactors- Two stage/phase anaerobic reactors, Sludge Digestion, Sludge disposal.</td>
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**Recommended Books:**

- Benefield L D and Randall C W, Biological Processes Design for wastewaters, Prentice-Hall, Inc. Eaglewood Cliffs
- Sincero A P and Sincero G A, Environmental Engineering, PHI, N Delhi
- CPHEEO, Manual on Sewerage and Sewage Treatment, GOI, N Delhi
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ESE-627  DESIGN OF EXPERIMENTS AND RESEARCH METHODOLOGY

Course Objective:

UNIT-I
Introduction, Objectives for experimental designs, Basic design concepts, Steps for the design of experiments, Types of experimental designs, Analysis of Means, Experimental designs and six sigma.
Statistical Inference, Generation of hypotheses, Testing of hypotheses, OC curve, Tests on means, Tests on variances, Assessing normality, ANOVA rationale, Confidence limits on means, Components of variance.

UNIT-II
Completely Randomized Design: Model for a completely randomized design with a single factor, ANOVA for a completely randomized design, Randomized block design, Incomplete block design, Latin square design, One way, Two way ANOVA, Balanced ANOVA.

UNIT-III

UNIT-IV
Methods of Research, Descriptive research design-survey, Case study, Content analysis, Ex-post Facto Research, Co relational and Experimental Research, Tests, Questionnaires, Checklists, Observation schedules, Selecting a standardized test, Data collection methods, Approaches to data collection, Interpretation of statistical analysis, Procedure for writing a research proposal, Types and components of research proposal, Procedure for writing a research report, Audiences and types of research reports, Format of research report and journal articles.

Recommended Books:
- Myers R H and Montgomery Dc, Response Surface Methodology, John Wiley
- CPSC: Developing Skills in Technician Education Research Modules 1 to 11 Singapore; Colombo Plan Staff College for Technician Education
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
ESE-629  ENVIRONMENTAL ENGINEERING LAB-II

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**Internal Evaluation: 25 Marks**  
**External Examination: 25 Marks**  
**Duration of Examination: 03 Hours**

**EXPERIMENTS**

- To determine the pH of a given sample of sewage / soil.  
- To determine the various forms of alkalinity and acidity in sewage sample.  
- To determine total, dissolved, suspended and volatile residues in sewage sample.  
- To determine the chemical oxygen demand (COD) of a given sewage sample.  
- To determine the biochemical oxygen demand (BOD) of a given sewage sample.  
- To determine the sulphate concentration in a given sample of soil.  
- Determination of concentration of suspended particulate matter in air.  
- Determination of gaseous pollutants from vehicles fitted with internal combustion engines.  
- Measurement of noise in residential, industrial and traffic areas.

**Recommended Books and Codes:**

- APHA Washington DC. Standard Methods for the Examination of Water and Wastewater  
- IS: 3025, Methods of Sampling and Test (Physical and Chemical) for Water and Wastewater.  
- IS: 2720, Method of Test for Soils  
- IS 5182 “Methods for Measurement of Air Pollution”  
- IS 14600 Automotive Vehicles-Exhaust Emissions-Gasous Pollutants from Vehicles Equipped with ICE.  
- IS 9989 Assessment of Noise with respect to Community Response.
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
ESE-631/633/635  SOLID AND HAZARDOUS WASTE MANAGEMENT

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**Internal Evaluation: 50 Marks**  
**External Examination: 50 Marks**  
**Duration of Examination: 03 Hours**

**Course Objective:**

<table>
<thead>
<tr>
<th>UNIT-I</th>
<th>Types and Sources of solid and hazardous wastes, Need for solid and hazardous waste management, Legislations on management and handling of municipal solid wastes, Hazardous wastes, And biomedical wastes.</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIT-II</td>
<td>Waste generation rates, Composition, Hazardous Characteristics, TCLP tests, Waste sampling, Source reduction of wastes, Recycling and reuse. Handling and segregation of wastes at source, Storage and collection of municipal solid wastes.</td>
</tr>
<tr>
<td>UNIT-IV</td>
<td>Disposal in landfills, Site selection, Design and operation of sanitary landfills, Secure landfills and landfill bioreactors, Leachate and landfill gas management, Landfill closure and environmental monitoring, Landfill remediation Elements of integrated waste management.</td>
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**Recommended Books:**
## B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
ESE-631/633/635  AIR QUALITY MANAGEMENT

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### Course Objective:

- **UNIT-I**  
  Air pollutants - Sources and classification of pollutants and their effect on human health vegetation and property- Effects - Reactions of pollutants and their effects- Smoke, Smog and ozone layer disturbance - Greenhouse effect - Ambient and stack sampling.

- **UNIT-II**  
  Atmospheric diffusion of pollutants - Transport, Transformation and deposition of air contaminants - Air sampling & pollution measurement methods - Ambient air quality and emission standards - Air pollution indices, Air act.

- **UNIT-III**  
  Control principles - Removal of gaseous pollutants by adsorption, Absorption, Reaction and other methods. Particulate emission control- settling chambers, Cyclone separation, Wet collectors, Fabric filters, Electrostatic precipitators and other removal methods like absorption, Adsorption, Precipitation, Biological air pollution control technologies - bioscrubers, Biofilters, And Indoor air quality.

- **UNIT-IV**  

### Recommended Books:

- Rao C S, Environmental pollution control Engineering, New age international Ltd, New Delhi
Course Objective:

UNIT-I
Soil as a multiphase system- Soil-environment interaction; Properties of water in relation to the porous media; Water cycle with special reference to soil medium. Soil mineralogy- significance of mineralogy in determining soil behaviour; Mineralogical characterization.

UNIT-II
Mechanisms of soil-water interaction- Diffuse double layer models; Force of attraction and repulsion; Soil-water-contaminant interaction, Theories of ion exchange; Influence of organic and inorganic chemical interaction.

UNIT-III
Introduction to unsaturated soil mechanics- water retention property and soil-water characteristic curve; flow of water in unsaturated soil. Concepts of waste containment facilities; desirable properties of soil; contaminant transport and retention; contaminated site remediation.

UNIT-IV
Introduction to advanced soil characterization techniques- volumetric water content; gas permeation in soil; electrical and thermal properties; pore-size distribution; contaminant analysis.

Recommended Books:
- Fang H Y, Introduction to Environmental Geotechnology, CRC Press
- Daniel D E, Geotechnical Practice for Waste Disposal, Chapman and Hall
- Rowe R K, Quigley R M and Booker Clay, Barrier Systems for Waste Disposal Facilities, JRE & FN Spon
- Reddi L N and Inyang H F, Geoenvironmental Engineering - Principles and Applications, Marcel Dekker Inc
**Course Objective:**

This course will help students understand the use of microorganisms in removing various pollutants.

**UNIT-I**
Introduction- Engineering of bioremediation processes, Current bioremediation practice and applications; Microbial systems of bioremediation.

**UNIT-II**
Factors influencing bioremediation (environmental factors, Physical factors and chemical factors); Genetic responses of microorganisms to the presence of pollutants (plasmid coded inducible degradative enzymes).

**UNIT-III**
Application of genetically engineered microorganisms for hazardous waste management; Microbial transformation reactions (aerobic and anaerobic bio-transformations); Microbial detoxification of specialty chemicals (insecticides, Herbicides, Fungicides, Polychlorinated biphenyls, Heavy metals).

**UNIT-IV**
Bioremediation systems and processes (solid, Liquid and slurry phase bioremediation); Microbial cleaning of gases (biofiltration and bioscrubbing); In situ bioremediation; Laboratory scale bio-treatability studies for bioremediation; Management of bioremediation project.

**Recommended Books:**
- Crawford R L and Crawford D L, Bioremediation: principles and applications, Cambridge University Press
- Singh Ajay, Kuhad Ramesh C, Ward Owen P, Advances in Applied Bioremediation
- Anderson W D, Bioremediation: Innovative Site Remediation Technology, American Academy of Environmental Engineers
- Sikdar and Irwin, Bioremediation: Principles and Practice, Technomic Publications, Lancaster, PA, USA
## B TECH: CHEMICAL ENGINEERING
### M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
### ESE-641/643/645  INDOOR AIR QUALITY

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**Internal Evaluation:** 50 Marks  
**External Examination:** 50 Marks  
**Duration of Examination:** 03 Hours

### Course Objective:

### UNIT-I
Indoor activities of inhabitants - Levels of pollutants in indoor and outdoor air, Design and operation of buildings for improvements of public health, Indoor air quality policy issues, Sustainability.

### UNIT-II
Air pollutants in indoor environments- private residences- offices, Schools-public buildings ventilation. Control of several pollutant classes, Radon, Toxic organic gases, Combustion by products microorganisms such as molds and infectious bacteria.

### UNIT-III

### UNIT-IV
Humidity-Bio aerosols, Infectious disease transmission, Special indoor environments, A/C units in indoor, Measurement methods, Control technologies, Control strategies.

### Recommended Books:
- Thaddes Godish, Indoor air and Environmental Quality, CRC press
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
ESE-641/643/645  CONTAMINANT TRANSPORT MODELING

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Internal Evaluation: 50 Marks  
External Examination: 50 Marks  
Duration of Examination: 03 Hours

Course Objective:

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<tr>
<td>UNIT-II</td>
<td>Model complexity, Model resolution, Coupled and uncoupled models, Linear and nonlinear models, Solution techniques, Calibration, Application and evaluation of environmental control, Bioremediation.</td>
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<tr>
<td>UNIT-III</td>
<td>Numerical models: FDM, FEM and Finite volume techniques, Explicit vs. implicit methods, Numerical errors, High resolution techniques.</td>
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<tr>
<td>UNIT-IV</td>
<td>Stream quality modeling using software QUAL2K, Groundwater transport modeling using various softwares such as VISULA, MODFLOW.</td>
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Recommended Books:
- Freeze R A and Cherry J A, Groundwater, Prentice Hall
- Vedat Batu, Applied flow and solute transport modeling in aquifers: fundamental principles and analytical and numerical methods, Taylor & Francis
The primary objective of this course is to enhance the student ability to analyze and carry out independent investigations etc. Each student will carry out independent work which should involve creativity, Innovation and ingenuity. A dissertation supervisor (s) having at least post-graduate qualification, From industry/research organization shall be assigned to the student approved by the competent authority. In no case, The candidate can have more than two dissertation supervisors. Industry oriented projects should be encouraged for the purpose.

The whole Dissertation work will be carried out and reported in two phases in 9th semester and 10th semester. Dissertation work (Phase-I) in 9th semester shall comprise of literature survey, Problem formulation, Finalization of goals to be achieved, Outlines of the methodology to be used for achieving the targeted goals and final decision about S/W, H/W tools to be used for dissertation work in 10th semester. The entire work will be documented in the form of report.

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## Course Objective:

### UNIT-I

### UNIT-II

### UNIT-III

### UNIT-IV

### Recommended Books:
- Kulkarni Vijay & Ramachandra T V, Environmental Management, Teri Press
- Krishnamoorthy Bala, Environmental Management, Prentice hall of India
### Course Objective:

#### UNIT-I
Land Processes - Subsurface and Channel Processes- Precipitation - Rain gauge network, Abstractions, Infiltration, Evaporation, Transpiration, Process and models
Unit Hydrograph & S curve hydrograph, Dimensionless unit hydrograph, GUIH, Watershed Model and Conceptual Models.

#### UNIT-II

#### UNIT-III
Pumping tests, Analysis for unconfined and non leaky and leaky confined aquifer and water table aquifer, Locating hydro geologic boundaries, Well design criteria.

#### UNIT-IV
Natural and Artificial Recharge of Ground water- Salt water intrusion, Application of Finite Difference in ground water.

### Recommended Books:
- Singh Vijay, Elementary Hydrology, Prentice Hall
- Raghunath, Ground Water, Mc Graw Hill
- Bear J, Hydraulics of Ground water, Mc Graw Hill
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ESE-632/634/636  INDUSTRIAL WASTE MANAGEMENT

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Course Objective:

UNIT-I

Industrial wastes: characteristics and composition of different industrial effluents, Effects of disposal of industrial effluents, Prevention versus control of industrial pollution, Linkage between technology and pollution prevention, Standards for disposal of industrial effluents.

UNIT-II


UNIT-III


UNIT-IV


Recommended Books:

- Rao M N and Dutta A K, Industrial Wastewater Treatment, Oxford and IBH publishing company, New Delhi
- Lund Herbert F, Industrial Pollution Control Handbook, McGraw
### Course Objective:

| UNIT-IV | Surface Water Contamination - Modeling Surface Water Contamination, Greenhouse Gas and Global Warming, Spatial Ecosystem Modeling with GIS, Models in Ecosystem Science |

### Recommended Books:

- Richmond Barry, An Introduction to Systems Thinking, USA: High Performance Systems Inc.
- Botkin Daniel B and Keller Edward A, Environmental Science: Earth as a Living Planet. USA: Wiley
- Aber John and Melillo Jerry, Terrestrial Ecosystems, USA: Academic Press
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ESE-642/644/646  ENVIRONMENTAL BIOTECHNOLOGY

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Internal Evaluation: 50 Marks
External Examination: 50 Marks
Duration of Examination: 03 Hours

Course Objective:

UNIT-I

UNIT-II
Biotechnological remedies for environmental pollution: decontamination of groundwater, Bioremediation, Production of proteins, Biofertilizers, Physical, Chemical and microbiological factors of composting, Health risk, Pathogens, Odor management, Microbial cell/enzyme technology, Adapted microorganisms, Biological removal of nutrients, Algal biotechnology, Extra cellular polymers, Biogas technology.

UNIT-III
Concept of rDNA technology - expression vectors, Cloning of DNA, Mutation, Construction of microbial strains, Radioactive probes, Protoplast fusion technology, Applications.

UNIT-IV
Environmental effects and ethics of microbial technology - genetically engineered organisms- Microbial containment-Risk assessment.

Recommended Books:
- Chaudhury G R, Biological degradation and Bioremediation of toxic chemicals, Dioscorides Press, Oregon
- Blaine Metting F (Jr.,) Soil Microbiology Ecology, Marcel Dekker Inc
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
ESE-642/644/646  ENVIRONMENTAL SYSTEMS ANALYSIS AND APPLIED STATISTICS

Internal Evaluation: 50 Marks  
External Examination: 50 Marks  
Duration of Examination: 03 Hours

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Course Objective:


UNIT-II  Probabilistic models - fuzzy models, Simulation models. Random variable, Two dimensional random variables, Standard probability distributions-Binomial Poisson and normal distributions, Moment generating function.


UNIT-IV  Regression and correlation, Rank correlation, Multiple and partial correlation, Analysis of variance-one way and two way classifications, Experimental design, Latin square design, Time series analysis. Modern tools- Neural networks, Genetic Algorithm - Case studies.

Recommended Books:
- Thoman R V, Systems Analysis & water Quality control, McGraw Hill
- Venkatraman M K, Numerical Methods in Science and Engineering, National Publisher Company
B TECH: CHEMICAL ENGINEERING
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING
ESE-642/644/646 DESIGN OF AIR POLLUTION CONTROL SYSTEMS

Internal Evaluation: 50 Marks
External Examination: 50 Marks
Duration of Examination: 03 Hours

Course Objective:

UNIT-I
Industrial sources of air pollution- Emission factors-regulations- control strategies-
policies.

UNIT-II
Particulate Pollutant Control: Settling chambers - laminar and turbulent flow-
Filtration, Interception, Impaction, Convective diffusion, Collection of particles by
cylindrical fibres and granular beds, Electrostatic precipitation, Cyclones, Wet
collectors.

UNIT-III
Gaseous Pollutant Control: Gas absorption in tray and packed towers- Absorption
with/without chemical reaction- Removal of SO2 - Adsorption in fixed beds-
Breakthrough.

UNIT-IV
Removal of HCs/ VOCs- NOX removal - Wet scrubbers, Integrated air pollution
control systems.

Recommended Books:
- Wang Lawrence K, Perelra Norman C, Hung Yung-Tse, Air pollution control Engineering,
  Tokyo
- Nevers Noel de, Air pollution control Engineering, McGraw Hill, New York
B TECH: CHEMICAL ENGINEERING  
M TECH: ENVIRONMENTAL SCIENCE & ENGINEERING  
ESE-660 DISSERTATION (PHASE-II)  

The complete dissertation work shall comprise of literature survey, Problem formulation, Methodology used, S/W, H/W tools used, Results and discussion followed by the conclusions & further scope of work in that area. The submission of dissertation in 10th semester shall be allowed only after ensuring that the research work carried out by the candidate has attained the level of satisfaction of the 'Dissertation Supervisor (s)' and proof of communication/acceptance of the research paper (if any, And certified in the report) in the relevant refereed journal/ conference.

The final dissertation external examination in 10th semester shall be taken by a panel of examiners comprising of concerned Supervisor (s), One external examiner (from the relevant field) nominated/approved by the competent authority. Hard copies of dissertation, One for each supervisor (s), Examiner and the university/ department, Are required to be submitted by the student before the final dissertation external examination. The candidate shall appear before the examining committee for oral examination and presentation on the scheduled date.