### SEMESTER I

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## LIST OF ELECTIVES

{Common to M.TECH (CHEMICAL ENGG, PRPC & EST)}

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A candidate will be permitted to register one elective course only under each group*, # and $.
UNIT I  NON-IDEAL REACTORS 9
The Residence Time Distribution as a factor of performance, residence time functions and relationship between them in reactor, basic models for non-ideal flow, conversion in non-ideal reactors.

UNIT II  KINETICS OF HETEROGENEOUS REACTIONS 9
Catalytic reactions, rate controlling steps, Langmuir-Hinshelwood model, Rideal-Eiley mechanism, steady state approximation, noncatalytic fluid-solid reactions, shrinking and unreacted core model.

UNIT III  EXTERNAL DIFFUSION EFFECTS IN HETEROGENEOUS REACTIONS 9
Mass and heat transfer coefficients in packed beds, quantitative treatment of external transport effects, modeling diffusion with and without reaction.

UNIT IV  INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS 9
Interpellet mass and heat transfer, evaluation of effectiveness factor, mass and heat transfer with reaction.

UNIT V  ANALYSIS AND DESIGN OF HETEROGENEOUS REACTORS 9
Isothermal and adiabatic fixed bed reactors, non-isothermal and non-adiabatic fixed bed reactors. Two-phase fluidized bed model, slurry reactor model, trickle bed reactor model. Industrial applications.

TOTAL : 45 PERIODS

REFERENCES
UNIT IV PHASE EQUILIBRIUM
VLE - Equations of state, corresponding states, Henry's Law, lattice theory, criticality, high pressure VLE. Other phase equilibriums- SLE/LLE/VLLE. Tutorials for application of principles.

UNIT V CHEMICAL EQUILIBRIUM
Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium. Tutorials for application of principles.

TOTAL : 45 PERIODS

REFERENCES
1. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad, 2005

CL8103 ADVANCED TRANSPORT PHENOMENA

UNIT I INTERPHASE TRANSPORT IN ISOTHERMAL SYSTEMS

UNIT II MACROSCOPIQUE BALANCES FOR ISOTHERMAL FLOW SYSTEMS AND POLYMERIC LIQUIDS


UNIT III INTERPHASE TRANSPORT IN NONISOTHERMAL SYSTEMS
UNIT IV MACROSCOPIC BALANCES FOR NONISOTHERMAL SYSTEMS


UNIT V INTERPHASE TRANSPORT IN NONISOTHERMAL MIXTURES

Definition of Transfer Coefficients in One Phase, Analytical Expressions for Mass Transfer Coefficients, Correlation of Binary Transfer Coefficients in One Phase, Evaporation from a Freely Falling Drop, Mass Transfer in Creeping Flow through Packed Beds, Mass Transfer to Drops and Bubbles, Definition of Transfer Coefficients in Two Phases, Determination of the Controlling Resistance, Estimation of the Interfacial Area in a Packed Column, Estimation of Volumetric Mass Transfer Coefficients. Case studies

TOTAL: 45 PERIODS

TEXT BOOK

REFERENCES
UNIT V  PARTIAL DIFFERENTIAL EQUATIONS – FINITE ELEMENT METHOD


TOTAL : 60 PERIODS

REFERENCES

CL8161  INSTRUMENTAL METHODS OF ANALYSIS LAB  L T P C
0 0 2 1

LIST OF EXPERIMENTS
1. UV-Visible spectrophotometer
2. Laser particle size diffraction analyzer
3. Gas chromatography
4. High performance liquid chromatography
5. Atomic absorption spectrophotometer.
6. Halogen moisture analyzer
7. Thermo gravimetric analyzer
8. Automated capillary microflow porometer
9. Electrochemical workstation

TOTAL : 30 PERIODS

CL8201 ADVANCED PROCESS CONTROL  L T P C
3 0 0 3

UNIT I  ADVANCED CONTROL STRATEGIES  9
Feed forward, cascade, dead time compensation, split range, selective and override control; automatic tuning and gain scheduling

UNIT II  INTERNAL MODEL CONTROL  9
Model based control – IMC structure – development and design; IMC based PID control, MPC

UNIT III MULTIVARIABLE CONTROL  9
Control loop interaction – general pairing problem, relative gain array and application, sensitivity. Multivariable control – zeros and performance limitations, directional sensitivity and operability, decoupling

UNIT IV DISCRETE SYSTEMS  9
UNIT V  DIGITAL FEEDBACK CONTROLLERS 9
Design of digital feedback controllers, digital approximation of classical, effect of
taking, Case study of Industrial Instrumentation and Control system, DCS, PLC,
shutdown system.

TOTAL : 45 PERIODS

REFERENCES
   2003
2. Stephanopolous, G., “Chemical Process Control”, Prentice Hall of India, New Delhi,
   1985.

CL8202 ADVANCED SEPARATION PROCESSES LT P C 3 0 0 3

UNIT I  GENERAL 12
Review of conventional processes, recent advances in separation techniques based on
size, surface properties, ionic properties and other special characteristics of substances.
process concept, theory and equipment used in cross flow filtration, cross flow
electrofiltration, dual functional filter, surface based solid-liquid separations involving a
second liquid, sirofloc filter.

UNIT II  MEMBRANE SEPARATIONS 8
Types and choice of membranes, plate and frame, tubular, spiral wound and hollow fibre
membrane reactors and their relative merits, commercial, pilot plant and laboratory
membrane pemeators involving dialysis, reverse osmosis, nanofiltration, ultrafiltration,
ultrafiltration, microfiltration and Donnan dialysis, economics of membrane operations, ceramic
membranes.

UNIT III  SEPARATION BY ADSORPTION TECHNIQUES 8
Mechanism, types and choice of adsorbents, normal adsorption techniques, affinity
chromatography and immuno chromatography, types of equipment and commercial
processes, recent advances and process economics

UNIT IV  IONIC SEPARATIONS 8
Controlling factors, Types of equipment employed for electrophoresis, dielectrophoresis,
Ion Exchange chromatography and electrodialysis, Commercial processes and
applications

UNIT V  OTHER SEPARATION TECHNIQUES 9
Separations involving lyophilization, pervaporation and permeation techniques for solids,
liquids and gases, industrial viability and examples, zone melting, adductive
crystallization, other separation processes, supercritical fluid extraction, oil spill
management, industrial effluent treatment by modern techniques.

TOTAL : 45 PERIODS

REFERENCES
CL8203 CHEMICAL PROCESS DESIGN L T P C
3 0 0 3

UNIT I INTRODUCTION
The Hierarchy of Chemical process Design- Overall process Design, approaches to design.

UNIT II SYNTHESIS OF REACTION – SEPARATION SYSTEMS
Process recycle, Batch processes, Reaction path, reactor performance,

UNIT III DISTILLATION SEQUENCING
Using simple columns, using columns with more than two products, homogeneous fluid mixtures, Separation of heterogeneous mixtures, Thermally coupled columns.

UNIT IV HEAT EXCHANGER NETWORK & UTILITIES – ENERGY TARGETS
Heat recovery pinch, The Problem table Algorithm, Utilities Selection, Energy targets capital & total Cost targets.

UNIT V HEAT EXCHANGER NETWORK & UTILITIES – CAPITAL AND TOTAL COST TARGETS
Number of Heat Exchanger Units, Area Targets, Number of Shells Targets, Capital Cost Targets, Total Cost Targets.

TOTAL : 45 PERIODS

REFERENCES

CL8211 SEMINAR L T P C
0 0 2 1

Students are expected to present two seminars along with report on any recent topic in chemical engineering.
UNIT I  INTRODUCTION 3
Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II  STEADY STATE LUMPED SYSTEMS 9
Degree of freedom analysis, single and network of process units, systems yielding linear and non-linear algebraic equations, flowsheeting – sequential modular and equation oriented approach, tearing, partitioning and precedence ordering, solution of linear and non-linear algebraic equations.

UNIT III  UNSTEADY STATE LUMPED SYSTEMS 9
Analysis of liquid level tank, gravity flow tank, jacketed stirred tank heater, reactors, flash and distillation column, solution of ODE initial value problems, matrix differential equations, simulation of closed loop systems.

UNIT IV  STEADY STATE DISTRIBUTED SYSTEM 7
Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

UNIT V  UNSTEADY STATE DISTRIBUTED SYSTEM 11
Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations.

UNIT VI  OTHER MODELING APPROACHES 6
Empirical modeling, parameter estimation, population balance and stochastic modeling.

TOTAL : 45 PERIODS

REFERENCES

CL8311  PROJECT WORK (PHASE I)  L T P C 0 0 1 2
Students have to do a research-based project in the department or in an industry and submit a report at the end of Phase I

CL8411  PROJECT WORK (PHASE II)  L T P C
Phase II of Project Work is a continuation of Phase I of Project. Students submit a report at the end of Phase II.

UNIT I
Basics of Jurisprudence—Environmental law relation with other disciplines—Criminal law—Common Law—Relevant sections of the code of civil procedure, criminal procedure code—Indian Penal code.

UNIT II
Fundamental Rights—Directive principles of state policy—Article 48(A) and 51-A (g) Judicial enforcibility—Constitution and resources management and pollution control—Indian forest policy (1990)—Indian Environmental policy (1992).

UNIT III

UNIT IV

UNIT V
Relevant notifications in connection with Hazardous Wastes (Management and handling), Biomedical Wastes (Management and Handling), Noise pollution, Eco-labelling, and EIA.

TOTAL: 45 PERIODS

REFERENCES
UNIT I

UNIT II
Process Variables Measurement—Temperature systems— Thermocouples, Thermo resistive system, Filled-system thermometers, Radiation thermometry, Location of temperature measuring devices in equipments, Pressure system – Mechanical pressure elements Pressure Transducers and Transmitters, Vacuum measurement, Resonant wire pressure Transducer, Flow system – Differential producers, Variable area flow meters, Velocity, vortex, mass, ultrasonic & other flow meters, positive displacement flow meters, Open – channel flow measurements, Force systems, Strain gauges Humidity Moisture system, Humidity Measurement, Moisture measurement system, Rheological system, Viscosity measurement, Radiation system, Nuclear radiation instrumentation.

UNIT III
Analytical instrumentation – Analysis instruments, Sample conditioning for process analyzers, X-ray Analytical methods, Quadrupole mass spectrometry, Ultra violet Absorption Analysis, Infra red process analyzers, Photometric reaction product analysers Oxygen analyzers, Oxidation – reduction potential measurements, pH measuring systems, Electrical conductivity and Resistivity measurements, Thermal conductivity, gas analysis, Combustible, Total hydro carbon, and CO analyzer, Chromatography.

UNIT IV

UNIT V
Sensors, Transmitters and control valves - Pressure, Flow, Level, Temperature and Composition sensors, Transmitters, Pneumatic and electronic control valves, Types, Actuator, accessories, Instrumentation symbols and Labels.

TOTAL : 45 PERIODS

REFERENCES
UNIT I

UNIT II

UNIT III
Green Chemistry, Green Chemistry Methodologies, Quantitative/Optimization-Based Frameworks for the Design of Green Chemical Synthesis Pathways, Green Chemistry Pollution Prevention in Material Selection for Unit Operations, Pollution Prevention for Chemical Reactors, Pollution Prevention for Separation Devices, Pollution Prevention Applications for Separative Reactors, Pollution Prevention in Storage Tanks and Fugitive Sources.

UNIT IV

UNIT V

TOTAL: 45 PERIODS

REFERENCES
UNIT III
Photochemistry, photolysis, fundamentals of semiconductor photocatalysis, photochemical processes for water and wastewater treatment, photooxidation reactions, photocatalytic reactions, photo-initiated oxidations, heterogeneous and homogeneous photocatalysis and kinetic studies.

UNIT IV
Fenton processes: homo and heterogeneous process, effect of system composition and process, identification of degradation products.

Photoelectrocatalysis process: photooxidation and photomineralization of organic matter in water and air: aqueous systems, substrate oxidation and mineralization, comparative studies of photo-initiated AOPs, biodegradability and toxicological studies.

UNIT V
Application of AOPs for VOC reduction and odour treatment, case studies – textile, pharmaceutical and petroleum and petrochemical industries.

TOTAL : 45 PERIODS

REFERENCES
UNIT IV  ATMOSPHERIC DYNAMICS
Kinematics of the large-scale horizontal flow – Dynamics of horizontal flow – primitive equations – atmospheric general circulation – numerical weather prediction.

UNIT V  CLIMATE
The present day climate – Climate variability – Climate equilibrium, sensitivity – Green house warming – Climate changes – Climate monitoring and prediction – weather systems – tropical cyclones – case studies: tsunami and sea level rising, Acid rain– The concept of El Nino.

TOTAL : 45 PERIODS

REFERENCES

CL8073  BIO ENERGY CONSERVATION TECHNIQUES  L T P C
3 0 0 3

UNIT I  INTRODUCTION

UNIT II  BIOMETHANATION

UNIT III  COMBUSTION

UNIT IV  GASIFICATION

UNIT V  PYROLYSIS AND CARBONIZATION

TOTAL : 45 PERIODS

[Signature]
TEXT BOOKS
1. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis HoknoodChichester, 1984.

REFERENCES
2. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981
5. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S

CL8074 BIOCHEMICAL ENGINEERING
L T P C
3 0 0 3

UNIT I
9

UNIT II
9
The kinetics of enzyme catalysed reactions – the enzyme substrate complex and enzyme action, simple enzyme kinetics with one and two substrates, determination of elementary step rate constants. Isolation and utilization of Enzymes – production of crude enzyme extracts, enzyme purification, applications of hydrolytic enzymes, other enzyme applications, enzyme production – intercellular and extra cellular enzymes.

UNIT III
9
Metabolic pathways and energetics of the cell, concept of energy coupling, ATP and NAD, Photosynthesis, Carbon metabolism, EMP pathway, Tricarboxylic cycle and electron transport chain, aerobic and anaerobic metabolic pathways, transport across cell membranes, Synthesis and regulation of biomolecules.

UNIT IV
9
Typical growth characteristics of microbial cells, Factors affecting growth, Batch and continuous cell growth, nutrient media, enrichment culture, culture production and preservation Immobilization technology – Techniques of immobilization, Characterization and applications, Reactors for immobilized enzyme systems.

UNIT V
9
Introduction to biological reactors, Continuously stirred aerated tank bioreactors, mixing power correlation, Determination of volumetric mass transfer rate of oxygen from air bubbles and effect of mechanical mixing and aeration on oxygen transfer rate, heat transfer and power consumption, Multiphase bioreactors and their applications. Downstream processing and product recovery in bio processes.

TOTAL : 45 PERIODS
REFERENCES

CL8075  CLIMATE CHANGE AND ADAPTATION  L T P C
               3 0 0 3

UNIT I  EARTH'S CLIMATE SYSTEM  9

UNIT II  OBSERVED CHANGES AND ITS CAUSES  9

UNIT III  IMPACTS OF CLIMATE CHANGE  9

UNIT IV  CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES  9

UNIT V  CLEAN TECHNOLOGY AND ENERGY  9

TOTAL : 45 PERIODS

REFERENCES
2. Al core ‘inconvenient truth” – video form
3. IPCC Fourth Assessment Report – The AR4 Synthesis Report,
UNIT I  CONSERVATION LAWS AND TURBULENCE MODELS  9
Governing equations of fluid flow and heat transfer – mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Characteristics of turbulent flows, time averaged Navier Strokes equations, turbulence models—one and two equation, Reynolds stress, LES and DNS

UNIT II  FINITE DIFFERENCE APPROXIMATION  9
Mathematical behaviour of PDE, finite difference operators, basic aspects of discretization by FDM, explicit and implicit methods, error and stability analysis.

UNIT III  FINITE VOLUME METHOD  15
Diffusion problems – explicit and implicit time integration; Convection-diffusion problems – properties of discretisation schemes, central, upwind, hybrid, QUICK schemes; Solution of discretised equations.

UNIT IV  FLOW FIELD COMPUTATION  6
Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows.

UNIT V  GRID GENERATION  6
Physical aspects, simple and multiple connected regions, grid generation by PDE solution, grid generation by algebraic mapping.

TOTAL : 45 PERIODS

REFERENCES

UNIT I  CONCEPTS AND TERMINOLOGY  5
Review of hypothesis testing – P Value, “t” Vs paired “t” test, simple comparative experiment, planning of experiment – steps. Terminology - factors, levels, variables, Design principles – replication, randomization, blocking, confounding, Analysis of variance, sum of squares, degrees of freedom.
UNIT II  SINGLE FACTOR EXPERIMENTS  10
Completely randomized design, Randomized block design, effect of coding the observations, Latin Square design, orthogonal contrasts, comparison of treatment means – Duncan’s multiple range test, Newman- Keuel’s test, Fisher’s LSD test, Tukey’s test.

UNIT III  FACTORIAL EXPERIMENTS  10
Main and interaction effects, Rules for sum of squares and expected mean square, two and three factor full factorial design, 2k designs with two and three factors, Yate’s algorithm, practical applications.

UNIT IV  SPECIAL EXPERIMENTAL DESIGNS  10
Blocking and confounding in 2k design, nested design, split – plot design, two level fractional factorial design, fitting regression models, introduction to response surface methods- Central composite design.

UNIT V  TAGUCHI TECHNIQUES  10
Introduction, Orthogonal designs, data analysis using ANOVA and response graph, parameter design – noise factors, objective functions (S/N ratios), multi-level factor OA designs, applications.

TOTAL : 45 PERIODS

TEXT BOOK
1. Douglas C.Montgomery, Design and Analysis of Experiments, John Wiley & Sons,2005

REFERENCES
CONTROL
Compressed tablets; wet granulation; dry granulation or slugging; advancement in granulation; direct compression, tablet presses formulation; coating pills; capsules sustained action dosage forms; parenteral solutions, oral liquids; injections; ointments; standard of hygiene and manufacturing practice. Packing; packing techniques; quality control.

UNIT V PHARMACEUTICAL PRODUCTS & PHARMACEUTICAL ANALYSIS
Vitamins; cold remedies; laxatives; analgesics; nonsteroidal contraceptives; external antiseptics; antacids and others. Analytical methods and tests for various drugs and pharmaceuticals – spectroscopy, chromatography, fluorimetry, polarimetry, refractometry, pHmetry

TOTAL : 45 PERIODS

TEXT BOOK

REFERENCES

CL8079 ECOLOGY AND ENVIRONMENT

UNIT I
Aim - scope and applications of Ecology, Ecological Engineering and Ecotechnology and their relevance to human civilization - Development and evolution of ecosystems - Principles and concepts pertaining to communities in ecosystem - Energy flow and material cycling in ecosystems - Productivity in ecosystems.

UNIT II
Classification of ecotechnology - Principles and components of Systems and Modeling - Structural and functional interactions in environmental systems - Human modifications of environmental systems.

UNIT III
Self organizing processes - Multiple seeded microcosms- Interface coupling in ecological systems - Concept of energy - Adapting ecological engineering systems to potentially catastrophic events - Agro ecosystems - Determination of sustainable loading of ecosystems.

UNIT IV
Principles and operation of soil infiltration systems - wetlands and ponds - source separation systems aqua cultural systems - detritus based treatment for solid wastes - Applications of ecological engineering marine systems.

UNIT V
Case studies of integrated ecological engineering systems

TOTAL : 45 PERIODS
REFERENCES

CL8080 ELECTROCHEMICAL ENGINEERING  L T P C  3 0 0 3

UNIT I
9

UNIT II
9
Mass transfer in electrochemical systems: diffusion controlled electrochemical reaction –the importance of convention and the concept of limiting current. over potential, primarysecondary current distribution –rotating disc electrode.

UNIT III
10

UNIT IV
8

UNIT V
9
Electrodes used in different electrochemical industries: Metals-Graphite –Lead dioxide –Titanium substrate insoluble electrodes –Iron oxide –semi conducting type etc. Metal finishing- cell design. types of electrochemical reactors, batch cell, fluidized bed electrochemical reactor, filter press cell, Swiss roll cell, plug flow cell, design equation, figures of merits of different type of electrochemical reactors.

TOTAL : 45 PERIODS

TEXT BOOKS

REFERENCES
UNIT I
Definition and classification of pollutants, method of pollutants analysis, pollution monitoring, electrochemical monitoring, monitoring contaminated sites, seawater monitoring, rainfall monitoring, role of sensors in environmental pollution.

UNIT II
Conventional methods for pollution control, incinerator, pyrolysis, air stripping, microbial treatment, precipitation coagulation, adsorption, membrane process. Advanced techniques of pollution treatment, treatment of polluted sites. Introduction to electrochemical systems, current charge transport potential, electrode interface, electrochemical kinetics. Water disinfections, general consideration, and chemical disinfections by products, taste and odour removal and indicator organism.

UNIT III
Electrochemical treatment of waste water, direct electrolysis, indirect electrolysis, mechanism of electro oxidation, anodic oxidation of organic and inorganic pollutants, cathodic reduction, reversible, irreversible process, Fenton agents. Electrochemical reduction of metal ions, membrane assisted process, electro dialysis and electrochemical ion exchange process, electro chemical disinfections of water, UV dose and disinfection kinetics, photo electro chemical disinfection of water.

UNIT IV
Electrochemical remediation of soil, photochemical treatment of organic pollutants, photo electro chemical reduction, electro chemical treatment of mixed and hazardous waste, electrochemical generation of hypochloric acid, photo electro chemical treatment of waste water.

UNIT V
Materials for electrochemical treatment, electrodes used in different types of industries, type of electro chemical reactor, batch cell, fluidized bed electro chemical reactor, filter press cell, Swiss role cell, Plug flow cell, design equation, electrochemical reactors for pollutant treatment, figure of merits of different types of electro chemical reactors.

TOTAL : 45 PERIODS

REFERENCES
UNIT I INTRODUCTION OF ELECTROCHEMICAL ENGINEERING 9
Industrial importance of electrolytic processes, Basic concepts and definitions, Criteria for reactor performance, Electrochemical and catalytic reactions and reactors. Fundamentals of reaction kinetics, rate of electrochemical reaction, electrochemical thermodynamics, practical cell voltage requirements and polarization, single electrochemical reactions, potentiostatic operations of first order reaction and galvanostatic operation of first order reactions.

UNIT II ASPECTS OF MASS AND HEAT TRANSFER IN ELECTROLYTIC CELL SYSTEMS 9
Basic aspects of fluid dynamics, mass transfer-mass flux in a fully developed turbulent regime, entrance and exit effects, obtaining numerical values of mass transfer coefficient by calculation and experiment, mass transfer in two phase flow, energetic and energy balances, CSTR with general order reactions, effect of mass transport and side reaction.

UNIT III RATE PROCESSES AND REACTION MODELS 9
Rate processes, kinetics of elementary reactions, reaction mechanism and rate laws, transition state theory, derivation of kinetic relationships, reaction models.

UNIT IV REACTOR MODELS 9
General considerations, batch reactor and continuous reactor. Fed batch, continuous, cell recycle, plug flow reactor, two stage reactors,. Reactor dynamics and stability. Reactors with non ideal mixing. Other types of reactors- fluidized bed reactors; packed bed reactors, bubble column reactors, trickle bed reactors.

UNIT V ELECTROLYTIC REACTOR DESIGN, SELECTION AND SCALE UP 9
Electrolytic reactor designs, Electrolytic reactor selection, scale up of electrolytic reactors, effect of scale up on mass transfer, effect of scale up on current distribution, Multiple electrode models and time factors.

TOTAL : 45 PERIODS

TEXT BOOKS
UNIT I  THE ELECTROCHEMICAL CELL AND REACTOR  9

UNIT II  ELECTROCHEMICAL CELL DESIGN AND ENGINEERING  9

UNIT III  ELECTROCHEMICAL MEMBRANE PROCESS  9

UNIT IV  THE TREATMENT OF INDUSTRIAL PROCESS STREAMS AND EFFLUENTS  9

UNIT V  ORGANIC AND INORGANIC ELECTROCHEMICAL SYNTHESIS  9

TOTAL : 45 PERIODS

TEXT BOOKS
UNIT I  FUNDAMENTAL CONCEPTS  9
Electron transfer, mass transport, interplay of electron transfer and mass transport, control adsorption, electro catalysis, phase formation in electrode reactions, chemical reactions, the properties of electrolytic solutions, assessment of cell voltage, electrochemistry at surfaces on open circuit.

UNIT II  THE CHLOR-ALKALI INDUSTRY  9

UNIT III  THE EXTRACTION, REFINING AND PRODUCTION OF METALS  9
Electro winning, cementation, electore fining, electrode position of metal powders. Principles of mineral processing: comminution, physical separation techniques, flotation, dewatering. Selection of extraction processes. Hydrometallurgy and electrometallurgy including leaching, solution purification, solvent extraction, metal winning and refining. Pyrometallurgical operations including roasting, smelting, converting and refining and refractory issues.

UNIT IV  INORGANIC ELECTROLYTIC PROCESS  9
Fluorine, water electrolysis, sodium chlorate, sodium bromate, per acids and their salts, permanganate, potassium dichromate and chromic acid, hydrogen peroxide, ozone, manganese dioxide, synthesis of metal salts via anodic dissolutions.

UNIT V  WATER PURIFICATION, EFFLUENT TREATMENT AND RECYCLING OF INDUSTRIAL PROCESS STREAMS  9
Metal ion removal and metal recovery, hypochlorite, and low tonnage chlorine electrolysis, electrodialysis. The treatment of liquors containing dissolved chromium, electrolytic methods of phase separation, flue gas desulphurisation, other electrochemical process.

TOTAL : 45 PERIODS

TEXT BOOKS
UNIT I
Energy sources; coal oil, natural gas; nuclear energy; hydro electricity, other fossil fuels; geothermal; supply and demand; depletion of resources; need for conservation; uncertainties; national and international issues.

UNIT II
Forecasting techniques, energy demand, magnitude and pattern, input and output analysis, energy modeling and optimal mix of energy sources. Energy - various forms, energy storage, structural properties of environment.

UNIT III
Bio-geo-chemical cycles; society and environment population and technology. Energy and evolution, growth and change, patterns of consumption in developing and advances countries, commercial generation of power requirements and benefit.

UNIT IV
Chemical industries, classification, conservation in unit operation such as separation, cooling tower, drying, conservation applied to refineries, petrochemical, fertilizers, cement, pulp and paper, food industries, chloro alkali industries, conservation using optimization techniques.

UNIT V
Sources of continuous power, wind and water, geothermal, tidal and solar power, MHD, fuel cells, hydrogen as fuel. Cost analysis, capacity; production rate, system rate, system cost analysis, corporate models, production analysis and production using fuel inventories, input-output analysis, economics, tariffs.

TOTAL : 45 PERIODS

REFERENCES

UNIT I
FUNDAMENTALS OF ENHANCED OIL RECOVERY

UNIT II
WATER FLOODING
Properties, sampling and analysis of oil field water; Injection waters; Water flooding - Sweep efficiency, Predictive techniques, Improved water flood processes, Performance of some important water floods.
UNIT III  ENHANCED OIL RECOVERY OPERATIONS-1  
Flooding – miscible, CO₂, polymer, alkaline, surfactants, steam;

UNIT IV  ENHANCED OIL RECOVERY OPERATIONS-2  
Gas injection, in-situ combustion technology, microbial method.

UNIT V  PROBLEMS IN ENHANCED OIL RECOVERY 
Precipitation and deposition of Asphaltenes and Paraffins, Scaling problems, Formation of damage due to migration of fines, Environmental factors.

TOTAL : 45 PERIODS

REFERENCES
Requirements for and benefits of the provision of information, instruction, training and supervision. Factors to be considered in the development of effective training programmes. Principles and methods of effective training. Feedback and evaluation mechanism.

TOTAL: 45 PERIODS

REFERENCES
1. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and Madelyn L. Graffia, William Andrew Inc. NY, 1995

CL8088 ENVIRONMENTAL BIOTECHNOLOGY L T P C
3 0 0 3

UNIT I
Principles and concepts of environmental biotechnology - usefulness to mankind.

UNIT II

UNIT III

UNIT IV
Concept of DNA technology - plasmid - cloning of DNA - mutation - construction of microbial strains.

UNIT V
Environmental effects and ethics of microbial technology - safety of genetically engineered organisms.

TOTAL: 45 PERIODS

REFERENCES
UNIT I  ENVIRONMENT AWARENESS  9
Environment – friendly chemical Process; Hazard and risk analysis; Environmental Audit.

UNIT II  CHEMICAL ENGINEERING PROCESSES  9
Unit Operations – application of - Abatement of water pollution; Current strategies to control air pollution; Disposal of solid wastes

UNIT III  RECYCLING METHODOLOGY  9
Economic recovery and recycling of waste; Transport fuel- Bio-diesel for a cleaner environment.

UNIT IV  CLEAN TECHNOLOGY  9
Towards Eco- friendly products of chemical industry; Pesticides –Their transfer and Transformation in the environment, Biological and electrochemical technology for effluent treatments

UNIT V  POLLUTION PREVENTION  9
Mass exchange network synthesis for pollution control and minimization Implications of environmental constraints for process design, policies for regulation of environmental impacts, Concept of common effluent treatment; Environmental legislations, Role of Government and Industries

REFERENCES

UNIT I  ENVIRONMENTAL MANAGEMENT  3003
8
Environmental Legislations in India, Europe, USA and Canada – Development of Legislations, Standards and Guidelines

UNIT II  WATER POLLUTION PREVENTION  5
UNIT III
Factory Act 1987 of India, Occupational health and safety requirements and standards of ILO, Compliance of rules and guidelines of Factory Act applicable to industries.

UNIT IV
Principles of Environmental impact assessment and audit guidelines and legislature requirements for siting of industrial units in estates/complex. Preparatory procedures for EIA study, Evaluation of impact on air, water and land environment.

UNIT V
Principles of Environmental Auditing, Cleaner Technologies in Industrial Processes and evaluation of processes Auditing techniques in Preparing EA. Monitoring of ambient environment, including air, water and land, noise, liquid and solid waste management.

REFERENCES

TOTAL : 45 PERIODS

CL8091 ENVIRONMENTAL NANOTECHNOLOGY

UNIT I GENERAL
Background of nanotechnology, particle size and surface area, quantum dot. Converging science and technology, nanotechnology as a tool for sustainability, health, safety and environmental issues.

UNIT II SYNTHESIS AND FABRICATION OF NANOMATERIALS
Preparation of nano scale metal oxides, metals, CNT, functionalized nano porous adsorbents, nano composite- Chemical vapour deposition, sol gel, sonochemical, microwave, solvothermal, plasma, pulsed laser ablation, magnetron sputtering, electrospinning, Molecular imoring.

UNIT III CHARACTERISATION OF NANOMATERIALS
AFM, STM, SEM, TEM, XRD, ESCA, IR & Raman, UV-DRS, of nanomaterials for structural & chemical nature.

UNIT IV OTHER FEATURES OF NANO PARTICLES
Nanoparticle transport, aggregation & deposition. Energy applications-H₂ storage.

UNIT V ENVIRONMENTAL APPLICATIONS
Gas sensors, microfluidics and lab on chip, catalytic and photocatalytic applications, Nonmaterials for ground water remediation, nanomaterials as adsorbents, membrane process.

TOTAL : 45 PERIODS
REFERENCES
1. Environmental applications of nanomaterials-Synthesis, Sorbents and Sensors, edited by Glen E Fryxell and Guozhong Cao, worldscibooks, UK

CL8092 ENVIRONMENTAL POLICIES AND LEGISLATION L T P C
3 0 0 3

UNIT I INTRODUCTION

UNIT II WATER (P&CP) ACT, 1974
Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Water Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT III AIR (P&CP) ACT, 1981
Power & functions of regulatory agencies - responsibilities of Occupier Provision relating to prevention and control Scheme of Consent to establish, Consent to operate – Conditions of the consents – Outlet – Legal sampling procedures, State Air Laboratory – Appellate Authority – Penalties for violation of consent conditions etc. Provisions for closure/directions in apprehended pollution situation.

UNIT IV ENVIRONMENT (PROTECTION) ACT 1986
Genesis of the Act – delegation of powers – Role of Central Government - EIA Notification – Sitting of Industries – Coastal Zone Regulation - Responsibilities of local bodies mitigation scheme etc., for Municipal Solid Waste Management - Responsibilities of Pollution Control Boards under Hazardous Waste rules and that of occupier, authorisation – Biomedical waste rules – responsibilities of generators and role of Pollution Control Boards

UNIT V OTHER TOPICS
Relevant Provisions of Indian Forest Act, Public Liability Insurance Act, CrPC, IPC - Public Interest Litigation - Writ petitions - Supreme Court Judgments in Landmark cases.

TOTAL : 45 PERIODS

REFERENCES
1. CPCB, “Pollution Control acts, Rules and Notifications issued there under “Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.
UNIT I
Reaction engineering principles with applications to environmental systems, general reaction mechanisms, Rate Relationships: Concepts and Applications to Homogeneous Systems and Heterogeneous Systems with respect to chemical and biological reactions.

UNIT II
Ideal systems modeling and design, reactor concepts, ideal reactors, reaction rate measurements, Hybrid system modeling and design, Sequencing batch reactor, Reactors in series and reactors with recycle.

UNIT III
Non ideal system modeling and design, non ideal reactor behavior, RTD analysis, PFDR model.

UNIT IV

UNIT V
Biological reaction engineering; biological kinetics; enzyme kinetics; Michaelis-Menten equation; simple microbial kinetics; structured kinetic models biological reaction engineering; basic bioreactor concepts; bioreactor modeling; bioreactor operation; batch operation; semicontinuous operation; fed batch operation; continuous operation, and its environmental applications.

TOTAL : 45 PERIODS

REFERENCES
UNIT III
Overall risk contours for different failure scenarios – disaster management plan – emergency planning – onsite and offsite emergency planning, risk management ISO 14000, EMS models – case studies – marketing terminal, gas processing complex.

UNIT IV
Safety measures design in process operations. Accidents modeling – release modeling, toxic release and dispersion modeling, fire and explosion modeling.

UNIT V
Past accident analysis: Flux borough – Mexico – Bhopal analysis. Government policies to manage environmental risk

TOTAL : 45 PERIODS

REFERENCES

CL8095 ENVIROSMENTAL SCIENCE

UNIT I
Significance of Environmental Chemistry for Wastewater Engineering- Basic concepts of cell biology, metabolism, energetic of bio chemical reactions, enzymes and their importance in aerobic and anaerobic microbiological reactions, specific importance of co-factors, transport of materials in the organisms

UNIT II
Chemical equilibrium in gaseous and solutions, free energy change, entropy change of reactions in solutions,

UNIT III
Basic concepts of electro chemistry, Debye-Huckel Theory, solubility of strong electrolytes, acids and bases, buffers, pH, interpretation of pH data. Colloids, osmosis, viscosity of colloidal suspension, Brownian movement and diffusion sedimentation, surface forces, electrical properties of surfaces

UNIT IV
Colloids, osmosis, viscosity of colloidal suspension, Brownian movement and diffusion sedimentation, surface forces, electrical properties of surfaces

UNIT V
Sampling and characterization of water and wastewater by gravimetric, volumetric and colorimetric methods - Sampling and analysis of ambient air for SPM, SO2, and Oxides of nitrogen - Good laboratory practice - Analytical quality control.

TOTAL : 45 PERIODS
### CL8096  ENVIRONMENTAL SUSTAINABILITY  L T P C  3 0 0 3

**UNIT I**
Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems

**UNIT II**

**UNIT III**
Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary-Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation

**UNIT IV**
Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.

**UNIT V**

**REFERENCES**

### CL8097  FLUIDIZATION ENGINEERING  L T P C  3 0 0 3

**UNIT I**
INTRODUCTION
The Fluidized state, Nature of hydrodynamic suspension, particle forces, species of Fluidization, Regimization of the fluidized state, operating models for fluidization systems, Applications of fluidization systems.
UNIT II  HYDRODYNAMICS OF FLUIDIZATION SYSTEMS  12

UNIT III  SOLID MIXING AND SEGREGATION  8
Phase juxtapositions operation shifts, Reversal points, Degree of segregation, Mixing Segregation equilibrium, Generalised fluidization of poly disperse systems, liquid phase Mixing and gas phase mixing.

UNIT IV  HEAT AND MASS TRANSFER IN FLUIDIZATION SYSTEMS  12
Mass transfer – Gas Liquid mass transfer, Liquid Solid mass transfer and wall to bed mass transfer, Heat transfer – column wall – to – bed heat transfer, Immersed vertical cylinder to bed heat transfer, Immersed horizontal cylinder to bed heat transfer.

UNIT V  MISCELLANEOUS SYSTEMS  8
Conical Fluidized bed, Moving bed, Slurry bubble columns, Turbulent bed contactor, Two phase and Three phase inverse fluidized bed, Draft tube systems, Semifluidized bed systems, Annular systems, Typical applications, Geldart’s classification for power assessment, Powder characterization and modeling by bed collapsing.

TOTAL : 45 PERIODS

REFERENCES

CL8098  FUEL CELL TECHNOLOGY  L T P C
3 0 0 3

UNIT I  9
Overview of fuel cells: Low and high temperature fuel cells; Fuel cell thermodynamics - heat, work potentials, prediction of reversible voltage, fuel cell efficiency.

UNIT II  9
Fuel cell reaction kinetics - electrode kinetics, overvoltage, Tafel equation, charge transfer reaction, exchange currents, electro catalysis - design, activation kinetics, Fuel cell charge and mass transport - flow field, transport in electrode and electrolyte.

UNIT III  9
Fuel cell characterization - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modelling and system integration: - 1D model – analytical solution and CFD models.

UNIT IV  9
Balance of plant; Hydrogen production from renewable sources and storage; safety issues, cost expectation and life cycle analysis of fuel cells.
UNIT V
Fuel cell power plants: fuel processor, fuel cell power section (fuel cell stack), power conditioner; automotive applications, portable applications

TOTAL : 45 PERIODS

REFERENCES

CL8099 FUNDAMENTALS OF NANOSCIENCE L T P C 3 0 0 3

UNIT I INTRODUCTION
Nanoscale Science and Technology- Implications for Physics, Chemistry, Biology and Engineering-Classifications of nano structured materials- nano particles quantum dots, nanowires-ultra-thin films-multilayered materials. Length Scales involved and effect on properties: Mechanical, Electronic, Optical, Magnetic and Thermal properties. Introduction to properties and motivation for study (qualitative only).

UNIT II PREPARATION METHODS
Bottom-up Synthesis-Top-down Approach: Precipitation, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE.

UNIT III PATTERNING AND LITHOGRAPHY FOR NANOSCALE DEVICES
Introduction to optical/UV electron beam and X-ray Lithography systems and processes, Wet etching, dry (Plasma /reactive ion) etching, Etch resists-dip pen lithography.

UNIT IV PREPARATION ENVIRONMENTS
Clean rooms: specifications and design, air and water purity, requirements for particular processes, Vibration free environments: Services and facilities required. Working practices, sample cleaning, Chemical purification, chemical and biological contamination, Safety issues, flammable and toxic hazards, biohazards.

UNIT V CHARACTERISATION TECHNIQUES
X-ray diffraction technique, Scanning Electron Microscopy – environmental techniques, Transmission Electron Microscopy including high-resolution imaging, Surface Analysis techniques- AFM, SPM, STM, SNOM, ESCA, SIMS Nano indentation

TOTAL : 45 PERIODS

TEXT BOOKS
REFERENCES

CL8100 GAS TRANSPORTATION L T P C
3 0 0 3

UNIT I
Introduction, widespread use, the various types, the advantages and the special features of pipelines.

UNIT II
The fluid mechanics of various types of pipe flow including incompressible and compressible flows of Newtonian fluids, non-Newtonian fluids, flow of solid/liquid mixture (slurry), flow of solid/air mixture (pneumatic transport), and flow of capsules (capsule pipelines).

UNIT III
Various types of pipes (steel, concrete, PE, PVC, etc.), valves (gate, globe, ball, butterfly, etc.) and pressure regulators in pipelines. Blowers and compressors (for gases). Various kinds of flowmeters, sensors, pigs (scrapers) and automatic control systems used in pipelines.

UNIT IV
Various means to protect pipelines against freezing, abrasion and corrosion, such as cathodic protection. Planning, construction and operation of pipelines, including modern use of advanced technologies such as global positioning systems (GPS), directional drillings, automatic control using computers, and pipeline integrity monitoring such as leak detection.

UNIT V
Structural design of pipelines — load considerations and pipe deformation and failure. Economics of pipelines including life-cycle, Cost analysis and comparison of the cost-effectiveness of pipelines with alternative modes of transport such as truck or railroad. Legal, safety and environmental issues about pipelines.

TOTAL : 45 PERIODS

REFERENCES
UNIT I

UNIT II

UNIT III

UNIT IV

UNIT V
Case Studies on – Patents (Basumati rice, turmeric, Neem, etc.) – Copyright and related rights – Trade Marks – Industrial design and Integrated circuits – Geographic indications – Protection against unfair competition.

TEXT BOOK

REFERENCES
UNIT III MEMBRANE BIOREACTORS
Introduction and Historical Perspective of MBRs, Biotreatment Fundamentals, Biomass Separation MBR Principles, Fouling and Fouling Control, MBR Design Principles, Design Assignment, Alternative MBR Configurations, Commercial Technologies, Case Studies

UNIT IV PRETREATMENT SYSTEMS
Membrane Fouling – Pretreatment methods and strategies – monitoring of Pretreatment – Langlier Index, Silt Density Index, Chemical cleaning, Biofoulant control

UNIT V CASE STUDIES
Case studies on the design of membrane based water and wastewater treatment systems – zero Liquid effluent discharge Plants

TOTAL : 45 PERIODS

REFERENCES
1. Water Environment Federation (WEF), Membrane Systems for Wastewater Treatment, McGraw-Hill, USA, 2005

CL8106 MULTICOMPONENT DISTILLATION L T P C
3 0 0 3

UNIT I THERMODYNAMIC PRINCIPLES

UNIT II THERMODYNAMIC PROPERTY EVALUATION
Fundamental principles involved in the separation of multi component mixtures – Determination of bubble-point and Dew Point Temperatures for multi component mixtures – equilibrium flash distillation calculations for multi component mixtures – separation of multi component mixtures at total reflux.

UNIT III MINIMUM REFLUX RATIO FOR MCD SYSTEM

UNIT IV VARIOUS METHODS OF MCD COLUMN DESIGN
Theta method of convergence – Kb method and the constant composition method – Application of the Theta method to complex columns and to system of columns – Lewis Matheson method – Stage and reflux requirements – Short cut methods and Simplified graphical procedures.
UNIT V  VARIOUS TYPES OF MCD COLUMNS  

Design of sieve, bubble cap, valve trays and structured packing columns for multi component distillation – computation of plate efficiencies.

TOTAL : 45 PERIODS

TEXT BOOKS


CL8107  MULTIPHASE FLOW  L T P C  3 0 0 3

UNIT I  CHARACTERISTICS OF MULTIPHASE FLOWS  
Significance of multiphase flows, important non-dimensional numbers, parameters of characterization, particle size measurement, size distribution and moments, size distribution models.

UNIT II  PARTICLE FLUID INTERACTION  

UNIT III  MODELING OF MULTIPHASE FLOWS  
Flow patterns - identification and classification - flow pattern maps and transition - momentum and energy balance - homogeneous and separated flow models - correlations for use with homogeneous and separated flow models - void fraction and slip ratio correlations - influence of pressure gradient - empirical treatment of two phase flow - drift flux model - correlations for bubble, slug and annular flows.

UNIT IV  CONSERVATION EQUATIONS  
Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling.

UNIT V  MULTIPHASE SYSTEMS  
Flow regime and hydrodynamic characteristics of packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds; Conventional and novel measurement techniques for multiphase systems including CARPT, Laser Doppler anemometry, Particle Image Velocimetry.

TOTAL : 45 PERIODS

REFERENCES

UNIT I
Introduction to upstream economics analysis, energy overview of India – Time value of money, cash flow analysis, capital budgeting techniques, general probability, elements of oil and gas project cash flows.

UNIT II
Reserves classification methods, quantification, assessment of geoscience and reservoir engineering uncertainties – Assessment of reserves, production and demand in international market.

UNIT III
Inflation and cost escalation, oil market and OPEC, share of non OPEC countries in oil production – International oil and gas pricing mechanism – Geopolitics.

UNIT IV
Petroleum Fiscal system, classification and analysis – Reserves Auditing – Accounting systems for oil and gas.

UNIT V
Project Economic Evaluation and petroleum economic models – Decision analysis – Valuation of petroleum properties.

TOTAL : 45 PERIODS

REFERENCES
2. Cronquist, C., Estimation and classification of Reserves of Crude oil, Natural Gas, and Condensate, SPE (2001)
UNIT III  PLOT PLAN  
Development of plot plan for different types of fluid storage, equipment layout, process piping layout, utility piping layout. Stress analysis - Different types of stresses and its impact on piping, methods of calculation, dynamic analysis, flexibility analysis.

UNIT IV  PIPING SUPPORT  
Different types of support based on requirement and its calculation.

UNIT V  INSTRUMENTATION  
Final Control Elements; measuring devices, instrumentation symbols introduction to process flow diagram (PFD) and piping & instrumentation diagram (P&ID)

TOTAL : 45 PERIODS

TEXT BOOKS

CL8110  POLLUTION ABATEMENT

UNIT I  
Man and environment, types of pollution, pollution controls aspects, industrial pollution, pollution monitoring and analysis of pollutants, Indian pollution regulations.

UNIT II  
Water pollution- source of water pollution- measurement of quality- BOD- COD- colour and odor-PH- heavy metals-treatments etc (qualitatively). Industrial waste water treatment (qualitatively) and recycle.

UNIT III  
Solid wastes- quantities and characterizations – industrial –hazardous waste- radioactive waste- simple treatments and disposal techniques (qualitatively treatment).

UNIT IV  
Air pollution-types and sources of gaseous pollutants-particulate matter-hazardous air pollutants-global and atmospheric climatic change (Green house effect)-acid rain. Industrial exhaust –characterization and Methods of decreasing the pollutants content in exhaust gasses (qualitatively).

UNIT V  

TOTAL : 45 PERIODS

REFERENCES
UNIT I  GENERAL ASPECTS OF POLYMERS  
Classification, mechanisms and methods of polymerization, properties-molecular weight, 
glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II  APPLICATION ORIENTED POLYMERS  
Resins-PVC-Silicon oil and resin, fibrous polymers-nylon 66, polyacrylonitrile, adhesives-
epoxides, phenol formaldehyde, urea formaldehyde.

UNIT III  ELASTOMERS  
Natural rubber, styrene-butadiene, poly isopropene-neoprene, silicon rubber, 
thermoplastic elastomer.

UNIT IV  PROCESSING OF POLYMERS  
Processing additives, plasticizer, antiaging additives, surface and optical properties, 
modifiers, fire retardants, additives for rubber and elastomer, various molding 
techniques.

UNIT V  PHYSICAL AND CHEMICAL TESTING OF PLASTICS  
Mechanical properties, tensile strength and hardness, electrical properties, volume 
resistivity, dielectric strength, optical properties glass, light transmission and refractive 
index, chemical analysis-elemental and functional analysis.

TOTAL : 45 PERIODS

REFERENCES

UNIT I  INTRODUCTION  
Problem formulation, degree of freedom analysis, objective functions, constraints and 
feasible region, Types of optimization problem.

UNIT II  LINEAR PROGRAMMING  
Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III  NONLINEAR UNCONSTRAINED OPTIMIZATION  
Convex and concave functions unconstrained NLP, Newton’s method Quasi-Newton’s 
method, Examples.

UNIT IV  CONSTRAINED OPTIMIZATION  
Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian 
Methods.
UNIT V    MULTI OBJECTIVE OPTIMIZATION
Weighted Sum of Squares method, Epsilon constrain method, Goal attainment, Examples. Introduction to optimal control and dynamic optimization.

REFERENCES

TOTAL : 45 PERIODS

CL8113 PROJECT ENGINEERING OF PROCESS PLANTS

UNIT I
Project definition, Project Profile and standards, Feed back information (MIS), Evaluation and Modification, Selection, Criteria.

UNIT II

UNIT III
Plant Engineering Management, Objectives, Programme, Control, Plant Location and Site Selection, Layout diagrams, Selection and procurement of equipment and machineries, Installation, Recommission, Commissioning and performance appraisal, Strategies choice and Influence, Product planning and development, Provision and maintenance of service facilities.

UNIT IV
Process safety, Materials safety and Handling regulations, Safety in equipment and machinery operations, Design considerations of safety organization and control, Pollution, Pollution control and Abatement, Industrial Safety Standard Analysis.

UNIT V

TOTAL : 45 PERIODS

REFERENCES

CL8114 REMOTE SENSING AND GIS APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

UNIT I OVERVIEW OF REMOTE SENSING

UNIT II REMOTE SENSING TECHNOLOGY
Classification of Remote Sensing Systems, Energy recording technology, Aerial photographs, Photographic systems – Across track and along track scanning, Multispectral remote sensing, Thermal remote sensing, Microwave remote sensing – Active and passive sensors, RADAR, LIDAR, Satellites and their sensors, Indian space programme - Research and development

UNIT III DATA PROCESSING

UNIT IV GEOGRAPHICAL INFORMATION SYSTEM
GIS Concepts – Spatial and non spatial data, Vector and raster data structures, Data analysis, Database management – GIS software

UNIT V REMOTE SENSING AND GIS APPLICATIONS
Monitoring and management of environment, Conservation of resources, Sustainable land use, Coastal zone management – Limitations

TOTAL : 45 PERIODS

REFERENCES
UNIT I
General: Risk types, Completion, Permitting, Resource, Operating, Environmental, Manageable, Insurable, Risk Causes, Risk Analysis types and causes.

UNIT II

UNIT III
Risk Management: Emergency relief Systems, Diers program, Bench scale experiments, Design of emergency relief systems, Internal emergency planning, Risk management plan, mandatory technology option analysis, Risk management alternatives, risk management tools, risk management plans, Risk index method, Dowfire and explosion method, Mond index Method.

UNIT IV

UNIT V

TOTAL : 45 PERIODS

REFERENCES
UNIT I
Conventional and modern concepts of safety, Basic Principles and concepts in hazard identification, Chemical hazards, Process and operation hazard, Hazards from utilities like air, water, steam etc., Occupational health hazards, Hazard and operability Studies, Safety Audits.

UNIT II
Past Accident Analysis, Consequence Analysis of fire, gas/vapour, Dispersions and explosion, Vulnerability models, Fault and Event Tree Analysis.

UNIT III
Safety in plant design and layout. Risk Assessment.

UNIT IV
Safety measures in handling and storage of chemicals, Process plant, personnel Protection, First Aid.

UNIT V
Disaster mitigation, Emergency Preparedness plans.

TOTAL : 45 PERIODS

REFERENCES

UNIT I
PHYSICS AND CHEMISTRY OF SOIL
UNIT II INORGANIC AND ORGANIC GEOCHEMISTRY


UNIT III CONTAMINANT FATE AND TRANSPORT IN SOIL


UNIT IV GROUND IMPROVEMENT TECHNIQUES IN WASTE MANAGEMENT


UNIT V SOIL REMEDIATION TECHNOLOGIES


TOTAL : 45 PERIODS

REFERENCES


CL8118 SOLVENT EXTRACTION

UNIT I EQUILIBRIUM IN LIQUID-LIQUID SYSTEM

UNIT II DIFFERENTIAL / STAGE-WISE EQUILIBRIUM CONTACT OPERATIONS
Equilibrium stage-wise contact. Single and multiple contacts with co-current and counter
current flow of phases for immiscible and partially miscible solvent phases, Calculation
methods, Fractional extraction with reflux of raffinate and extract. Differential contact,
HETS, NETS, HTU, NTU concepts and Estimation of these parameters, Mass transfer
efficiency, Axial mixing and Residence time distribution in extractors and their
estimation.

UNIT III DISPERSION AND COALESCENCE IN EXTRACTORS
Characteristics of dispersion involving single and multiple nozzle distributors, Drop size
and formation and coalescence, Mean drop size at dispersion and their settling
velocities/relative characteristics velocities. Effect of drop oscillation, wobbling and
Internal circulation, Effect of surface active agents, Prediction of drop size and
characteristics velocity in spray, packed and mechanically agitated contactors as in
RDC, pulsed columns, solute transfer effects on drop dynamics.

UNIT IV DESIGN OF LIQUID EXTRACTION COLUMNS
Design of extractor height and diameter, Prediction of flow capacities in terms of flooding
rates, Regime of operating envelopes, Hydrodynamic design variables such as hold up,
characteristic velocities, pressure drop, Effect of direction of solute transfer on these
variables and their prediction methods, Correction of mass transfer data, Axial mixing
correction for column height, Interfacial area estimations, using slow, fast and
instantaneous reactions and their application with models for mass transfer coefficients.

REFERENCES
1. Laddha, G. S. and Degaleesan, T. E., "Transport Phenomena in Liquid Extraction",
3. Hanson, C., “Recent Advances in Liquid Extraction”, Pergamon Press, London,
1972.

TOTAL : 45 PERIODS
UNIT IV SOURCING, AND PRICING IN SUPPLY CHAIN 9
Supplier selection and Contracts - Design collaboration – Procurement process. Revenue management in supply chain.

UNIT V COORDINATION AND TECHNOLOGY IN SUPPLY CHAIN 10

TOTAL : 45 PERIODS

REFERENCES

TOTAL QUALITY MANAGEMENT L T P C
CL8120 3 0 0 3

UNIT I CONCEPTS OF TQM 5
Philosophy of TQM, Customer focus, organization, top management commitment, team work, quality philosophies of Deming, Crosby and Muller.

UNIT II TQM PROCESS 12
QC Tools, Problem solving methodologies, new management tools, work habits, quality circles, bench marking, strategic quality planning.

UNIT III TQM SYSTEMS 8
Quality policy deployment, quality function deployment, Standardization, designing for quality, manufacturing for quality.

UNIT IV QUALITY SYSTEM 10
Need for ISO 9000 system, Advantages, clauses of ISO 9000, Implementation of ISO 9000, quality costs, quality, auditing, case studies.

UNIT V IMPLEMENTATION OF TQM 10
Steps, KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.

TOTAL : 45 PERIODS

REFERENCES
UNIT I  SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES  6
Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II  COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES  8
Onsite handling, storage and processing – types of waste collection mechanisms - transfer Stations : types and location – manual component separation - volume reduction : mechanical, thermal – separation : mechanical, magnetic electro mechanical

UNIT III  ENERGY GENERATION TECHNIQUES  16

UNIT IV  HAZARDOUS WASTE MANAGEMENT  8

UNIT V  ULTIMATE DISPOSAL  7

TOTAL : 45 PERIODS

TEXT BOOKS

REFERENCES

UNIT I  INTRODUCTION  10
UNIT II  INDUSTRIAL WASTEWATER TREATMENT  10
Equalisation - Neutralisation - Oil separation - Flotation - Precipitation - Heavy metal
Removal – Refractory organics separation by adsorption - Aerobic and anaerobic
biological treatment - Sequencing batch reactors – High Rate reactors

UNIT III  ADVANCED WASTEWATER TREATMENT AND REUSE  8
Chemical oxidation - Ozonation - Photocatalysis - Wet Air Oxidation - Evaporation - Ion
Exchange – Membrane Technologies - Nutrient removal - Land Treatment.

UNIT IV  RESIDUALS MANAGEMENT  5
Residuals of industrial wastewater treatment - Quantification and characteristics of
Sludge - Thickening, digestion, conditioning, dewatering and disposal of sludge -
Management of RO rejects.

UNIT V  CASE STUDIES  12
Industrial manufacturing process description, wastewater characteristics and waste
treatment flow sheet for Textiles - Tanneries - Pulp and paper - metal finishing -
Petroleum Refining - Chemical industries - Sugar and Distilleries - Dairy - Iron and steel
-fertilizers - Industrial clusters and Industrial Estates.

TOTAL : 45 PERIODS

REFERENCES
2. Arceivala, S. J., "Wastewater Treatment for Pollution Control", Tata McGraw Hill,
1998.
4. Nelson Leonard Nemerow, Industrial waste treatment - Contemporary practice and

EY8077  HYDROGEN AND FUEL CELL  L T P C
3 0 0 3

UNIT I  HYDROGEN – BASICS AND PRODUCTION TECHNIQUES  9
Hydrogen – physical and chemical properties, salient characteristics. Production of
hydrogen – steam reforming – water electrolysis – gasification and woody biomass
conversion – biological hydrogen production – photo dissociation – direct thermal or
catalytic splitting of water.

UNIT II  HYDROGEN STORAGE AND APPLICATIONS  9
Hydrogen storage options – compressed gas – liquid hydrogen – Hydride – chemical

UNIT III  FUEL CELLS  9
History – principle – working – thermodynamics and kinetics of fuel cell process –
performance evaluation of fuel cell – comparison on battery Vs fuel cell

UNIT IV  FUEL CELL – TYPES  9
Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and
demerits
UNIT V APPLICATION OF FUEL CELL AND ECONOMICS

Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space. Economic and environmental analysis on usage of Hydrogen and Fuel cell. Future trends in fuel cells.

TOTAL : 45 PERIODS

TEXT BOOKS

REFERENCES

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**MG8071 OPERATIONS RESEARCH**

<table>
<thead>
<tr>
<th><strong>UNIT I</strong></th>
<th><strong>MATHEMATICAL PROGRAMMING</strong></th>
<th><strong>L T P C</strong></th>
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<tbody>
<tr>
<td></td>
<td>Introduction, Linear Programming, Solution by simplex method, Duality, Sensitivity analysis, Dual simplex method, Integer Programming, Branch and bound method, Geometric programming and its application.</td>
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<tr>
<th><strong>UNIT II</strong></th>
<th><strong>DYNAMIC PROGRAMMING</strong></th>
<th><strong>10</strong></th>
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<tbody>
<tr>
<td>Elements of DP models, Bellman’s optimality criteria, Recursion formula, Solution of multistage decision problem by DP method. Application is Heat Exchange Extraction systems.</td>
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<th><strong>UNIT III</strong></th>
<th><strong>PERT, CPM and GERT</strong></th>
<th><strong>9</strong></th>
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<tbody>
<tr>
<td>Network representation of projects, Critical path calculation, construction of the time-chart and resource leveling, Probability and cost consideration in project scheduling, Project control. Graphical Evaluation and Review Techniques.</td>
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<tr>
<th><strong>UNIT IV</strong></th>
<th><strong>ELEMENTS OF QUEUING THEORY</strong></th>
<th><strong>7</strong></th>
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<tr>
<td>Basic elements of the Queuing model, M/M/1 and M/M/C Queues.</td>
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<th><strong>UNIT V</strong></th>
<th><strong>ELEMENTS OF RELIABILITY THEORY</strong></th>
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<tbody>
<tr>
<td>General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.</td>
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TOTAL : 45 PERIODS

REFERENCES