UNIVERSITY DEPARTMENTS
ANNA UNIVERSITY : : CHENNAI 600 025
REGULATIONS - 2013
I TO IV SEMESTERS CURRICULUM AND SYLLABUS (FULL TIME)
M. TECH. PETROLEUM REFINING AND PETROCHEMICALS

**SEMESTER I**

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A candidate will be permitted to register one elective course only under each group*, # and $. 

UNIT I TYPES OF CORROSION AND TESTING METHODS
Basic principles of corrosion and its control – Forms of corrosion, uniform, Galvanic, Crevis, pitting, selective leaching, erosion, stress-corrosion, cracking – Cavitation phenomena & their effects – Corrosion testing – Field testing – Electrochemical techniques for measurement of corrosion rates, corrosion detection and components examination – Accelerated salt-spray testing.

UNIT II CORROSION PROTECTION METHODS
Corrosion inhibitors, electroplated coatings, conversion coatings, anodizing, hot dipping, spray metal coatings, zinc coating by alloying, electrophoretic coatings and electro painting, powder coating, electrical methods of corrosion protection, composite materials in corrosion minimization – Cathodic and Anodic protections.

UNIT III CORROSION IN SPECIFIC ENVIRONMENTS
Corrosion damage to concrete in industrial and marine environments and its protection; biological corrosion, halogen corrosion of metals, environmental degradation of materials, corrosion and inspection managements in chemical processing and petrochemical industries.

UNIT IV CORROSION IN SPECIFIC CASES AND CONTROL

UNIT V CORROSION AND COUNTRY’S ECONOMY
Corrosion protection management–process maintenance procedures under corrosion Environments

TOTAL : 45 PERIODS

TEXT BOOK

REFERENCE

UNIT I INTERPHASE TRANSPORT IN ISOThERMAL SYSTEMS

UNIT II MACROSCOPIC 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


PP8103 PETROLEUM REFINERY ENGINEERING L T P C 3 0 0 3

UNIT I

Origin, Exploration and production of petroleum, Types of crudes, Composition, characteristics, products pattern and characteristics, indigenous and imported crudes, Availability Vs Demands, Future outlook.
UNIT II
Engineering aspects of refining, Reaction stoichiometry; Chemical kinetics; Thermochemistry and chemical equilibrium; Mixing in flow systems; Reactor design. Crude heating, Primary distillation, principles, Separation of cuts, Gaps/ overlaps, Stripping, Desalting, heat balance in distillation, Energy input and recovery, Vacuum distillation, Types of trays, Draw offs, intermediate product quality control.

UNIT III
Lube oil and wax processing, Solvent extraction, Dewaxing, Deciling, Deasphalting, Clay contacting, principles, technologies, operating parameters, Feed and product qualities and yields. Asphalt Manufacture, product qualities, Air blowing technology, Tankage operations, Storage and handling of crude products.

UNIT IV
Fluid catalytic cracking, principles, recent developments, Feed stocks and product yields and qualities, Catalysts and operating parameters. Hydrocracking, principles, process requirements, product yields and qualities, Residcracking – implications and technology.

UNIT V

REFERENCES

PP8104 PETROLEUM THERMODYNAMICS

UNIT I INTRODUCTION
Behaviour of Gases and Liquids – Gas laws, Density, Mole percent, Weight percent, Volume percent, Specific gravity, Heat, Work Closed and Open Systems, First and Second Laws of thermodynamics, specific heats, Compressibility factor, PVT relationships, Vapour pressure, Claussius – Clayperson equation, heat of vaporization.

UNIT II CHEMICAL THERMODYNAMICS OF PETROLEUM HYDROCARBONS
UNIT III QUALITATIVE PHASE BEHAVIOUR OF HYDROCARBON SYSTEMS

Calculation of liquid and vapour composition of Bubble point and Dew point pressure for multi component system. Equilibrium constant

UNIT IV HYDROCARBON FLUID CHARACTERISTICS

Gas formation volume factor, Gas solubility, Oil formation volume factor, Viscosity

UNIT V PROPERTIES OF MIXTURES


TEXT BOOK


REFERENCES

1. Jean vidal, Thermodynamics Application in chemical Engineering and the petroleum industry, Institute Francais bu petrole publications,France 2003
4. Rao., Y.V.C., Chemical Engineering Thermodynamics, University Press, Hyderabad, 2005

MA8168 ADVANCED NUMERICAL METHODS

UNIT I ALGEBRAIC EQUATIONS


UNIT II ORDINARY DIFFERENTIAL EQUATIONS – IVPs

Runge Kutta Methods, step size control and estimates of error, numerical stability, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations;

UNIT III ORDINARY DIFFERENTIAL EQUATIONS – BVPs

Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, shooting technique.

TOTAL : 45 PERIODS
UNIT I V PARTIAL DIFFERENTIAL EQUATIONS – FINITE DIFFERENCE METHOD 12
Parabolic equations – Different explicit and implicit methods, alternating direction explicit and implicit methods; Elliptic equations – Point iterative methods, line iterative methods, ADI methods; First order hyperbolic equations – method of characteristics, different explicit and implicit methods; numerical stability analysis, method of lines.

UNIT V PARTIAL DIFFERENTIAL EQUATIONS – FINITE ELEMENT METHOD 12

REFERENCES

TOTAL : 60 PERIODS

CL8161 INSTRUMENTAL METHODS OF ANALYSIS LAB 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

PP8201 NATURAL GAS ENGINEERING 3 0 0 3

UNIT I INTRODUCTION 12
UNIT II GAS TREATMENT AND PROCESSING 12
General Hydrodynamic equations for flow of fluids through porous media, two dimensional flow problems and potential theory methods, gravity flow systems, systems of non uniform permeability, multiple well systems using computerized streamline tracking methods.

UNIT III MULTIPHASE SYSTEMS 11
Use of multiphase flow correlations to determine flow ratio and pressure traverse in flowing oil wells, gas condensate wells, gathering systems and pipe lines, application of correlations to the design of gas system

UNIT IV GAS TREATMENT 10
Reservoir fluid properties – PVT properties for oil gas systems, phase Behavior of complex hydrocarbon mixtures at high temperature and pressure - thermodynamic property evaluation, packages used in petroleum industry.

TOTAL : 45 PERIODS

REFERENCES

PP8202 PETROCHEMICALS L T P C
3 0 0 3

UNIT I 5
Petrochemical industries and their feed stocks survey of petrochemical industry. Resources and generation of different feed stocks-their purification, separation of individual components by adsorption, low temperature fractionation and crystallization.

UNIT II 6
Production and utilization of synthesis gas: generation of synthesis gas by steam reforming of naptha and natural gas, fuel oil partial oxidation. chemicals from synthesis gas, methanol via synthesis gas route, formaldehyde from methanol, chloromethane by direct chlorination of methane, trichloroethylene, perchloroethylene by pyrolysis of carbon tetra chloride. Fischer-Tropsch process

UNIT III 10
Petrochemical based on methane, ethylene, acetylene, propylene and butane: acetylene and methanol from methane, VCM, VAM, ethylene oxide and ethylene glycol, ethanol amides from ethylene. VCM, VAM, acrylonitrile etc. from acetylene. Isopropanol, Propylene oxide, Glycerine, acrylonitrile, Acrylic acid, etc. From propylene. Production of butadiene by dehydrogenation of butane, nitrogen.
## UNIT IV
Separation and utilization of aromatics: catalytic reforming operation-separation of BTX from Reformate .isolation of benzene, toluene, xylene. aromatics derived from thermal cracking of naptha, pyrolysis gasoline hydrogenation process. Alkylation of benzene. production of pthalic anhydride etc. synthetic detergents: classification of detergents production of KERYL Benzene Sulphonate etc., filter, binders, dyes, perfumes, etc. for detergents. Hard and soft detergents.

## UNIT V
Synthetic fibres, rubbers, plastics, resins: method, mechanism and types of polymerization , production of HDPE,LDPE, PP,PVC, polystyrene, poly butadiene, etc., manufacture of polyesters, nylons, acrylic fibres,etc. production of phenol formaldehyde resin, epoxy resin, production principle of ABS plastic, polycarbonates, etc. manufacturing techniques of butyl rubber, SBR, isoprene rubber, etc.

### REFERENCES

### TOTAL : 45 PERIODS

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**PP8203 PROCES DYNAMICS AND CONTROL**

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

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

### UNIT III MULTIVARIABLE CONTROL
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

### UNIT V DIGITAL FEEDBACK CONTROLLERS
Design of digital feedback controllers, digital approximation of classical, effect of sampling, Case study of Industrial Instrumentation and Control system, DCS, PLC, shutdown system.

### TOTAL : 45 PERIODS
REFERENCES

PP8204 SEPARATION PROCESS TECHNIQUES

UNIT I GENERAL
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
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 permeators involving dialysis, reverse osmosis, nanofiltration, ultrafiltration, microfiltration and Donnan dialysis, economics of membrane operations, ceramic membranes.

UNIT III SEPARATION BY ADSORPTION TECHNIQUES
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
Controlling factors, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes and applications

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

TOTAL : 45 PERIODS

REFERENCES
LIST OF EXPERIMENTS
1. Determination of flash point and fire point
2. Viscosity Determination
3. Aniline point determination
4. API gravity determination
5. Hydrogen sulphide content determination
6. Doctor’s test
7. Determination of calorific value
8. Bitumen testing
9. Carbon residue determination (Conradson apparatus)
10. Cloud point and pour point estimation
11. Congealing point of wax
12. Foaming characteristics of lube oil
13. Smoke point estimation
14. Corrosion testing of petroleum oil
15. Distillation characteristics
16. Moisture content determination

Minimum of 10 experiments

TOTAL : 30 PERIODS

UNIT I INTRODUCTION
Design Principles, Continuous Reaction Model, Intrinsic and Global Rate Concepts

UNIT II CHEMICAL ENGINEERING KINETICS
Heterogeneous Catalysis, Chemical and Physical Characteristics of Solid Catalysts, Activity, Specific Activity, Selectivity

Kinetics of Heterogeneous Catalytic Reactions, Mechanisms and Kinetic Models, Experimental Reactors and Transport Criteria, Determination of Intrinsic Kinetics

UNIT III TRANSPORT PROCESSES IN SOLID-CATALYZED SYSTEMS
External Transport Processes, Internal Transport Processes, Fluidized-Bed Reactors

UNIT IV TWO-PHASE CATALYTIC REACTORS

UNIT V TWO-PHASE STRUCTURED REACTORS
Engineered Catalysts, Micro-structured Catalytic Reactors - Monolith Reactors, Microreactors

TOTAL : 45 PERIODS
TEXTBOOK

REFERENCES

PP8302  MODELING AND SIMULATION OF INDUSTRIAL PROCESSES  L T P C
3 0 0 3

UNIT I  INTRODUCTION
Introduction to modeling and simulation, classification of mathematical models, conservation equations and auxiliary relations.

UNIT II  STEADY STATE LUMPED SYSTEMS
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
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

UNIT V  UNSTEADY STATE DISTRIBUTED SYSTEM
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.

TOTAL : 45 PERIODS
REFERENCES

PP8311 PROJECT WORK (PHASE I) L T P C
0 0 12 6
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

PP8411 PROJECT WORK (PHASE II) L T P C
0 0 24 12
Phase II of Project Work is a continuation of Phase I of Project. Students submit a report at the end of Phase II.

CL8068 INDUSTRIAL POLLUTION PREVENTION L T P C
3 0 0 3

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 enforceability-Constitution and resources management and pollution control-Indian

UNIT III
Administration regulations-constitution of pollution control Boards Powers, functions,
Accounts, Audit etc.-Formal Justice Delivery Mechanism Higher and Lower of judiciary-
Constitutional remedies writ jurisdiction Article 32,226,136 special reference to
madamus and certioror for pollution abatement-Equitable remedies for pollution control.

UNIT IV

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

TOTAL : 45 PERIODS

REFERENCES
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

CL8070 GREEN CHEMISTRY AND ENGINEERING L T P C
3 0 0 3

UNIT I

UNIT II

UNIT III

UNIT IV

UNIT V
REFERENCES

REFERENCES
UNIT I  INTRODUCTION  9

UNIT II  ATMOSPHERIC THERMODYNAMICS  9

UNIT III  ATMOSPHERIC CHEMISTRY  9
Composition of tropospheric air – Sources, transport and sinks of trace gases – Tropospheric aerosols – air pollution – tropospheric chemical cycles – stratospheric chemistry.

UNIT IV  ATMOSPHERIC DYNAMICS  9
Kinematics of the large-scale horizontal flow – Dynamics of horizontal flow – primitive equations – atmospheric general circulation – numerical weather prediction.

UNIT V  CLIMATE  9
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

UNIT I  INTRODUCTION  8

UNIT II  BIOMETHANATION  8
UNIT III  COMBUSTION  10

UNIT IV  GASIFICATION  10

UNIT V  PYROLYSIS AND CARBONIZATION  9

TOTAL : 45 PERIODS

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
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
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

UNIT II OBSERVED CHANGES AND ITS CAUSES

UNIT III IMPACTS OF CLIMATE CHANGE

UNIT IV CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES
UNIT V CLEAN TECHNOLOGY AND ENERGY

REFERENCES
2. Al core ‘inconvenient truth” – video form
3. IPCC Fourth Assessment Report – The AR4 Synthesis Report,

CL8076 COMPUTATIONAL FLUID DYNAMICS
UNIT I CONSERVATION LAWS AND TURBULENCE MODELS
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
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
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
Pressure velocity coupling, staggered grid, SIMPLE algorithm, PISO algorithm for steady and unsteady flows

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

REFERENCES
CL8077  DESIGN OF EXPERIMENTS  L T P C

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
UNIT I
INTRODUCTION
Development of drugs and pharmaceuticael industry; organic therapeutic agents uses and economics

UNIT II
DRUG METABOLISM AND PHARMACO KINETICS & MICROBIOLOGICAL AND ANIMAL PRODUCTS
Drug metabolism; physico chemical principles; pharma kinetics-action of drugs on human bodies. Antibiotics- gram positive, gram negative and broad spectrum antibiotics; hormones

UNIT III
IMPORTANT UNIT PROCESSES AND THEIR APPLICATIONS
Chemical conversion processes; alkylation; carboxylation; condensation and cyclisation; dehydration, esterification, halogenation, oxidation, sulfonation; complex chemical conversions fermentation.

UNIT IV
MANUFACTURING PRINCIPLES & PACKING AND QUALITY CONTROL
Compressed tablets; wet granulation; dry granulation or slugging; advancement in granulation; direct compression, tablet presses formulation; coating pills; capsules sustained action dosage forms; parential 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

UNIT I
ECOLOGY AND ENVIRONMENT
Aim - scope and applications of Ecology, Ecological Engineering and Ecotechnoloy 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
UNIT V
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

CL8081 ELECTROCHEMICAL ENVIRONMENTAL TECHNOLOGY L T P C 3 0 0 3

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.
REFERENCES

CL8082 ELECTROCHEMICAL PROCESS ENGINEERING FOR CHEMICAL ENGINEERS

UNIT I INTRODUCTION OF ELECTROCHEMICAL ENGINEERING
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
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
Rate processes, kinetics of elementary reactions, reaction mechanism and rate laws, transition state theory, derivation of kinetic relationships, reaction models.

UNIT IV REACTOR MODELS
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
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

CL8083 ELECTROCHEMICAL PROCESSES FOR CLEAN TECHNOLOGY

UNIT I THE ELECTROCHEMICAL CELL AND REACTOR

UNIT II ELECTROCHEMICAL CELL DESIGN AND ENGINEERING

UNIT III ELECTROCHEMICAL MEMBRANE PROCESS

UNIT IV THE TREATMENT OF INDUSTRIAL PROCESS STREAMS AND EFFLUENTS

UNIT V ORGANIC AND INORGANIC ELECTROCHEMICAL SYNTHESIS

TOTAL : 45 PERIODS
TEXT BOOKS

CL8084 ELECTROCHEMICAL TECHNOLOGY FOR CHEMICAL ENGINEERS

UNIT I FUNDAMENTAL CONCEPTS
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

UNIT III THE EXTRACTION, REFINING AND PRODUCTION OF METALS
Electro winning, cementation, electro refining, 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
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
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

CL8085 ENERGY MANAGEMENT

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  9

UNIT II  WATER FLOODING  9
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  10
Flooding – miscible, CO₂, polymer, alkaline, surfactants, steam;

UNIT IV  ENHANCED OIL RECOVERY OPERATIONS-2  10
Gas injection, in-situ combustion technology, microbial method.

UNIT V  PROBLEMS IN ENHANCED OIL RECOVERY  7
Precipitation and deposition of Asphaltenes and Paraffins, Scaling problems, Formation of damage due to migration of fines, Environmental factors.

TOTAL : 45 PERIODS

REFERENCES

UNIT I  INTRODUCTION  9

UNIT II  OCCUPATIONAL HEALTH AND HYGIENE  9

UNIT III  WORKPLACE SAFETY AND SAFETY SYSTEMS  9
Features of the satisfactory design of work premises HVAC, ventilation. Safe installation and use of electrical supplies. Fire safety and first aid provision. Significance of human factors in the establishment and effectiveness of safe systems. Safe systems of work for manual handling operations. Control methods to eliminate or reduce the risks arising
from the use of work equipment. Requirements for the safe use of display screen equipment. Procedures and precautionary measures necessary when handling hazardous substances. Contingency arrangements for events of serious and imminent danger.

**UNIT IV**  **TECHNIQUES OF ENVIRONMENTAL SAFETY**  **9**


**UNIT V**  **EDUCATION AND TRAINING**  **9**

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.

**REFERENCES**

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

**TOTAL : 45 PERIODS**

**CL8088**  **ENVIRONMENTAL BIOTECHNOLOGY**  **L T P C**

3 0 0 3

**UNIT I**  **5**

Principles and concepts of environmental biotechnology - usefulness to mankind.

**UNIT II**  **11**


**UNIT III**  **11**


**UNIT IV**  **9**

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

**UNIT V**  **9**

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

CL8089 ENVIRONMENTAL ENGINEERING L T P C
3 0 0 3

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
# CL8090 ENVIRONMENTAL MANAGEMENT

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## UNIT I
Environmental Legislations in India, Europe, USA and Canada – Development of Legislations, Standards and Guidelines

## UNIT II

## 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.

**TOTAL : 45 PERIODS**

## REFERENCES

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# CL8091 ENVIRONMENTAL NANOTECHNOLOGY

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## UNIT I
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
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 abalation, magnetron sputtering, electrospinning, Molecular imoring.
UNIT III  CHARACTERISATION OF NANOMATERIALS  9
AFM, STM, SEM, TEM, XRD, ESCA, IR & Raman, UV-DRS, of nanomaterials for structural & chemical nature.

UNIT IV  OTHER FEATURES OF NANO PARTICLES  9
Nanoparticle transport, aggregation & deposition. Energy applications-H₂ storage.

UNIT V  ENVIRONMENTAL APPLICATIONS  9
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  9

UNIT II  WATER (P&CP) ACT, 1974  8
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  8
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  13
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.
2. Shyam Divan and Armin Roseneranz “Environmental law and policy in India “Oxford
1994.

CL8093  ENVIRONMENTAL REACTION ENGINEERING  L T P C
3 0 0 3

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
Reactive interphase mass transfer, Fluid –solid surface reactions, Gas-liquid bulk phase
reactions, adsorption in porous solids, Fluid solid processes and gas-liquid processes.

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
2. Dunn I.J, Elmar Heinzle, John Ingham, Pfenosil J.E, ‘Biological Reaction
Engineering, Wiley inter science, 2005.
3. Martin A. A. and Robert P.H. Reaction Engineering for Pollution Prevention, Elsevier
UNIT I
Risk analysis introduction, quantitative risk assessment, rapid risk analysis – comprehensive risk analysis – identification, evaluation and control of risk

UNIT II
Risk assessment – introduction and available methodologies, Risk assessment steps, Hazard identification, Hazard assessment (consequence analysis), probabilistic hazard assessment (Fault tree analysis)

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

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

REFERENCES

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

TOTAL : 45 PERIODS

REFERENCES
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

UNIT III  SOLID MIXING AND SEGREGATION
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
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
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

UNIT I
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
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
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
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
CL8104 INTELLECTUAL PROPERTY RIGHTS

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.

TOTAL : 45 PERIODS

TEXT BOOK

REFERENCES

CL8105 MEMBRANE TECHNOLOGIES FOR WATER AND WASTEWATER TREATMENT

UNIT I INTRODUCTION
Solid Liquid separation systems-Filtration systems- Theory of Membrane separation – mass Transport Characteristics Cross Flow filtration-Membrane Filtration- Types and choice of membranes, porous, non porous, symmetric and assymmetric – Plate and Frame, spiral wound and hollow fibre membranes – Liquid Membranes

UNIT II MEMBRANE PROCESSES AND SYSTEMS
### REFERENCES

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

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### 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
   Company, 1981

CL8107  MULTIPHASE FLOW  

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  
Equation of motion for a single particle, calculation of drag, motion of a particle in two-
dimensions, effects of unsteady and non-uniform flow fields, effect of acceleration, effect
of coupling; Interaction between particles, mechanism of interaction, interparticle forces,
hard sphere model, soft sphere model, discrete element modeling, semi-empirical
methods, kinetic theory, force chains.

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
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and
   Particles, CRC Press, 2011
   2005
   2008.
   1969.
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  L T P C  3 0 0 3

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  9
Classification, mechanisms and methods of polymerization, properties-molecular weight, glass transition temperature, crystallinity, thermal, electrical and mechanical properties.

UNIT II  APPLICATION ORIENTED POLYMERS  9
Resins-PVC-Silicon oil and resin, fibrous polymers-nylon 66, polyacrylonitrile, adhesives-epoxides, phenol formaldehyde, urea formaldehyde.

UNIT III  ELASTOMERS  9
Natural rubber, styrene-butadiene, poly isopropene-neoprene, silicon rubber, thermoplastic elastomer.

UNIT IV  PROCESSING OF POLYMERS  9
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  9
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

CL8112  PROCESS OPTIMIZATION  L T P C  3 0 0 3

UNIT I  INTRODUCTION  5
Problem formulation, degree of freedom analysis, objective functions, constraints and feasible region, Types of optimization problem.

UNIT II  LINEAR PROGRAMMING  10
Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III  NONLINEAR UNCONSTRAINED OPTIMIZATION  10
Convex and concave functions unconstrained NLP, Newton’s method Quasi-Newton’s method, Examples.

UNIT IV  CONSTRAINED OPTIMIZATION  10
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  L T P C
3 0 0 3

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 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

CL8117 SOIL POLLUTION ENGINEERING

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


REFERENCES

CL8118  SOLVENT EXTRACTION  L T P C
3 0 0 3

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 envelops. 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

TOTAL : 45 PERIODS

CL8119  SUPPLY CHAIN MANAGEMENT  L T P C
3 0 0 3

UNIT I  INTRODUCTION

UNIT II  LOGISTICS MANAGEMENT

UNIT III  SUPPLY CHAIN NETWORK DESIGN

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

UNIT V  COORDINATION AND TECHNOLOGY IN SUPPLY CHAIN

REFERENCES

TOTAL : 45 PERIODS
# CL8120 TOTAL QUALITY MANAGEMENT

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

## UNIT II
**TQM PROCESS**
12
QC Tools, Problem solving methodologies, new management tools, work habits, quality circles, benchmarking, 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**

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# CL8121 WASTE MANAGEMENT AND ENERGY RECOVERY

## 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  

TOTAL : 45 PERIODS

TEXT BOOKS

REFERENCES

CL8122  WASTE WATER ENGINEERING  

UNIT I  INTRODUCTION  

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

UNIT III  ADVANCED WASTEWATER TREATMENT AND REUSE  

UNIT IV  RESIDUALS MANAGEMENT  
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  

TOTAL : 45 PERIODS
REFERENCES

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

UNIT I HYDROGEN – BASICS AND PRODUCTION TECHNIQUES 9

UNIT II HYDROGEN STORAGE AND APPLICATIONS 9

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 9
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
### UNIT I  MATHEMATICAL PROGRAMMING  
12

### UNIT II  DYNAMIC PROGRAMMING  
10
Elements of DP models, Bellman’s optimality criteria, Recursion formula, Solution of multistage decision problem by DP method. Application is Heat Exchange Extraction systems.

### UNIT III  PERT, CPM and GERT  
9
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.

### UNIT IV  ELEMENTS OF QUEUING THEORY  
7
Basic elements of the Queuing model, M/M/1 and M/M/C Queues.

### UNIT V  ELEMENTS OF RELIABILITY THEORY  
7
General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.

**TOTAL : 45 PERIODS**

**REFERENCES**