# M.TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY

## SEMESTER I

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## SEMESTER II

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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

UNIT II
Theory, Modeling of Ideal Suspended Growth Reactors, Modeling Suspended Growth Systems, Aerobic Growth of Heterotrophs in a Single Continuous Stirred Tank, Reactor Receiving Soluble Substrate, Multiple Microbial Activities in a Single Continuous Stirred Tank Reactor, Multiple Microbial Activities in Complex Systems, Techniques for Evaluating Kinetic and Stoichiometric Parameters

UNIT III
Applications: Suspended Growth Reactors, Design And Evaluation of Suspended Growth Processes, Activated Sludge, Biological Nutrient Removal, Aerobic-digestion, Anaerobic Processes, Lagoons

UNIT IV
Theory: Modeling of Ideal Attached Growth Reactors, Bio-film Modeling Aerobic Growth of Biomass in Packed Towers, Aerobic Growth of Heterotrophs in Rotating Disc Reactors, Fluidized Bed Biological Reactors,

UNIT V

TOTAL : 45 PERIODS

REFERENCES
1. Grady, C.P.L, Daigger, G and Lim, H.C, Biological Wastewater Treatment, 2nd Ed, Marcel Dekker, 1999

UNIT I

UNIT II
UNIT III
Overall risk analysis-generation of metrological data-ignition date-population data-consequences analysis and total risk analysis-overall risk contours for different failure scenarios-disaster management plan-emergency planning-n site & off site emergency planning, risk management ISO 140000, EMS models case studies-marketing terminal, gas processing complex, refinery.

UNIT IV
Hazard identification safety audits, checklist, what if analysis, vulnerability models event tree analysis, fault tree analysis, Past accident analysis: Fixborough-Mexico-Bhopal analysis.

UNIT V
Hazop-guide words, parameters, derivation-causes-consequences-recommendation, Hazop study-case studies-pumping system-reactor-mass transfer system.

REFERENCES

TOTAL : 45 PERIODS
REFERENCES

MA8168 ADVANCED NUMERICAL METHODS

UNIT I ALGEBRAIC EQUATIONS
Systems of linear equations – Jacobi, Gauss Seidel, SOR methods, Thomas algorithm for
tridiagonal systems; Systems of nonlinear equations - successive approximation method,
methods for improved convergence, Newton Method and its variants, continuation
methods for multiple solutions.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS – IVPS
RungeKutta 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.

UNIT IV PARTIAL DIFFERENTIAL EQUATIONS – FINITE DIFFERENCE
METHOD
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
Partial differential equations – Finite element method - orthogonal collocation method,
orthogonal collocation with finite element method, Galerkin finite element method.

TOTAL : 60 PERIODS

REFERENCES
3. Steven C. Chapra and Raymond P Canale, Numerical Methods for Engineers, 6th
2. Sampling and analysis of air pollutants ambient and stacks (SPM, RPM, SO$_2$, NO$_x$ and CO).
3. Physiochemical analysis of solid wastes.
4. Design of clarifier by using the data obtained through batch sedimentation.
5. Coagulation and flocculation for removal of suspended solids from water.
10. Treatment of waste water by Advanced Oxidation Technology.

**TOTAL: 60 PERIODS**

**REFERENCES**

UNIT III
Ventilation and Indoor Air Quality Control; An Overview of Indoor Air Quality; The Basics of HVAC Systems; IAQ Issues and Impacts on Occupants; Application of Audits to Developing an IAQ Profile; Developing Management Plans; IAQ Problems; Control; Quantification and Measurement, Air Pollution Dispersion-Dispersion Theory Basics- Air Quality Impact of Stationary Sources- Models and Resources

UNIT IV
Prevention Versus Control; Pollution Prevention: Principles of Pollution Prevention; Methods of Particulate Collection; Methods for Cleaning Gaseous Pollutants, Environmental Cost Accounting; Total Cost Accounting Terminology;

UNIT V

TOTAL : 45 PERIODS

REFERENCES

EV8202 ENVIRONMENTAL IMPACT ASSESSMENT L T P C 3 0 0 3

UNIT I
Environmental Impact Assessment (EIA) - Environmental Impact Statement (EIS) - Environmental Risk Assessment (ERA) - Legal and Regulatory aspects in India - Types and limitations of EIA - Terms of Reference in EIA- Issues in EIA - national – cross-sectoral - social and cultural.

UNIT II

UNIT III
Trends in EIA practice and evaluation criteria - capacity building for quality assurance. Expert System in EIA - use of regulations and AQM.
UNIT IV

UNIT V
Case studies of EIA of developmental projects

REFERENCES

EV8203 SEPARATION PROCESSES IN ENVIRONMENTAL APPLICATIONS

UNIT I
Pollution sources, Environmental separations-Historic perspective of environmental pollution- Separation mechanisms -Equilibrium-based processes, Rate-based processes Countercurrent operation, Productivity and selectivity, separating agents,

UNIT II
Degrees of freedom analysis, Phase equilibrium, Equilibrium-limited analysis, Minimum number of stages, Rate-limited processes, Batch and Continuous distillation, Extraction in Environmental applications, Leaching processes, McCabe–Thiele analysis

UNIT III
Absorption and stripping, packed columns, Adsorption principles, Sorbent selection-regeneration, Transport processes, Process design factors, Design of fixed-bed adsorber.

UNIT IV
Ion exchange- Objectives, Environmental applications, Ion-exchange mechanisms, Ion-exchange media, Equipment and design procedures; Extraction and leaching.

UNIT V

REFERENCES
UNIT I
Legal and Organizational foundation: Definition of solid waste - waste generation in a technological society - sources and types of solid waste – legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, batteries waste, E-waste and plastics, monitoring responsibilities.

UNIT II

UNIT III

UNIT IV
Hazardous waste treatment technologies - Design and operation of facilities for physical, chemical and thermal treatment of hazardous waste - Solidification, chemical fixation and encapsulation, incineration. Hazardous waste landfills: Site selection, design and operation - remediation of hazardous waste disposal sites.

UNIT V
Sampling and characterization of Solid Wastes; TCLP tests and leachate studies

TOTAL : 45 PERIODS

REFERENCES
EV8211 SEMINAR

Students are expected to present two seminars along with report on any recent topic in Environmental Science and Technology.

EV8301 MODELING OF ENVIRONMENTAL SYSTEMS

UNIT I

UNIT II

UNIT III

UNIT IV

UNIT V
Fuzzy System Modeling Introduction to fuzzy sets and systems, fuzzification, implication, connectives, defuzzification, rule-based fuzzy models with different approaches (Mamdani and Sugeno). Cluster analysis for the classification of ecological data,. Integration between fuzzy clustering and fuzzy models.

TOTAL : 45 PERIODS

REFERENCES
Students have to do a research project in the department or in an industry and submit a report at the end of the Phase I.

Students have to do a research project in the department or in an industry and submit a report at the end of the 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

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

CL8069  INDUSTRIAL INSTRUMENTATION  L T P C
3 0 0 3

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

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

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 I
Introduction to AOP, fundamentals of AOPs for water and wastewater treatment.

UNIT II
Photoinduced AOP. UV Photolysis H₂O₂, UV/O₃ processes, Ozonation, Fenton processes, Ultrasound processes and principles of sonochemistry.

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

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 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.

REFERENCES

TOTAL : 45 PERIODS

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

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

UNIT I

UNIT II
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
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

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

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

TOTAL : 45 PERIODS
CL8076  COMPUTATIONAL FLUID DYNAMICS  L T P C  3 0 0 3

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.

TOTAL : 45 PERIODS

REFERENCES

CL8077  DESIGN OF EXPERIMENTS  L T P C  3 0 0 3

UNIT I  CONCEPTS AND TERMINOLOGY
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

CL8078 DRUGS AND PHARMACEUTICAL TECHNOLOGY L T P C
3 0 0 3

UNIT I INTRODUCTION 9
Development of drugs and pharamaceutical industry; organic therapeutic agents uses and economics

UNIT II DRUG METABOLISM AND PHARMAKO KINETICS & MICROBIOLOGICAL AND ANIMAL PRODUCTS 9
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 9
Chemical conversion processes; alkylolation; carboxylation; condensation and cyclisation; dehydration, esterification, halogenation, oxidation, sulfonation; complex chemical conversions fermentation.

UNIT IV MANUFACTURING PRINCIPLES & PACKING AND QUALITY CONTROL 9
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  L T P C
3  0 0 3

UNIT I
10
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
10
Classification of ecotechnology - Principles and components of Systems and Modeling - Structural and functional interactions in environmental systems - Human modifications of environmental systems.

UNIT III
10
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
10
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
5
Case studies of integrated ecological engineering systems

TOTAL : 45 PERIODS

REFERENCES
UNIT I

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

UNIT III

UNIT IV

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
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
2. Pletcher, D., and Walsh, F., Industrial Electrochemistry, 2 nd Edn., Chapman and Hall,
   1990.
   Hall, 1995.
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

24
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, electrore 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

CL8085  ENERGY MANAGEMENT  L T P C
3 0 0 3

UNIT I  9
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  9
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  9
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  9
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  9
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.
REFERENCES

CL8086 ENHANCED OIL RECOVERY L T P C
3 0 0 3

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.

REFERENCES

CL8087 ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES L T P C
3 0 0 3

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.

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.

REFERENCES

TOTAL : 45 PERIODS
REFERENCES

CL8090 ENVIRONMENTAL MANAGEMENT L T P C 3 0 0 3

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
CL8091  ENVIRONMENTAL NANO-TECHNOLOGY  L T P C  3 0 0 3

UNIT I  GENERAL  9
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  9
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  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-H \textsubscript{2} 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
3. The Chemistry of Nanomaterials, Synthesis, Properties and applications. Edited by
   KGaA, Weinheim

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

UNIT I  INTRODUCTION  9
Indian Constitution and Environmental Protection – National Environmental policies –
Precautionary Principle and Polluter Pays Principle – Concept of absolute liability –
multilateral environmental agreements and Protocols – Montreal Protocol, Kyoto
agreement, Rio declaration – Environmental Protection Act, Water (P&CP) Act, Air
(P&CP) Act – Institutional framework (SPCB/CPCB/MoEF)

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  
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.

REFERENCES
1. CPCB, “Pollution Control acts, Rules and Notifications issued there under “Pollution Control Series – PCL/2/1992, Central Pollution Control Board, Delhi, 1997.

CL8093  ENVIRONMENTAL REACTION ENGINEERING  

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.

REFERENCES

TOTAL : 45 PERIODS

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

REFERENCES

TOTAL : 45 PERIODS

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>LTTC</th>
<th>Total Periods</th>
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<tbody>
<tr>
<td>CL8097</td>
<td>FLUIDIZATION ENGINEERING</td>
<td>3003</td>
<td>45</td>
</tr>
</tbody>
</table>

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.

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

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  10
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  10
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  9
Introduction, widespread use, the various types, the advantages and the special features of pipelines.

UNIT II  9
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  9
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  9
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  9
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
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

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
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
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

CL8108  PETROLEUM ECONOMICS

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)
CL8109  PIPING AND INSTRUMENTATION  L T P C
                                           3 0 0 3

UNIT I        FUNDAMENTALS OF PIPING ENGINEERING  9
Definitions, Piping Components their introduction, applications. Piping MOC, Budget
Codes and Standards, Fabrication and Installations of piping.

UNIT II       PIPE HYDRAULICS AND SIZING  9
Pipe sizing based on velocity and pressure drop consideration cost, least annual cost
approach, pipe drawing basics, development of piping general arrangement drawing,
dimensions and drawing of piping.

UNIT III      PLOT PLAN  9
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  9
Different types of support based on requirement and its calculation.

UNIT V        INSTRUMENTATION  9
Final Control Elements; measuring devices, instrumentation symbols introduction to
process flow diagram (PFD) and piping & instrumentation diagram (P&ID)

TOTAL : 45 PERIODS

TEXT BOOKS
3.  Luyben, W. L.,” Process Modeling Simulation and Control for Chemical Engineers,

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

REFERENCES

TOTAL : 45 PERIODS

CL8111 POLYMER TECHNOLOGY

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 isopropane-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.

TOTAL : 45 PERIODS

REFERENCES
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
REFERENCES

CL8115 RISK ANALYSIS AND MANAGEMENT LTPC
3 0 0 3

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

CL8116 SAFETY AND HAZARD CONTROL

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
UNIT I  EQUILIBRIUM IN LIQUID-LIQUID SYSTEM  12

UNIT II  DIFFERENTIAL / STAGE-WISE EQUILIBRIUM CONTACT OPERATIONS  9
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  12
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  12
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.

TOTAL : 45 PERIODS

REFERENCES
UNIT III  SUPPLY CHAIN NETWORK DESIGN  10  

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

CL8120 TOTAL QUALITY MANAGEMENT  L T P C
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, 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  
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  

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  

UNIT II   HYDROGEN STORAGE AND APPLICATIONS  

UNIT III   FUEL CELLS  
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  
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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**UNIT I**
**MATHEMATICAL PROGRAMMING**

**UNIT II**
**DYNAMIC PROGRAMMING**
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**
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**
Basic elements of the Queuing model, M/M/1 and M/M/C Queues.

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

**TOTAL : 45 PERIODS**

**REFERENCES**