# M.TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY

## SEMESTER I

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**TOTAL CREDITS TO BE EARNED FOR THE AWARD THE DEGREE = 67**

## LIST OF ELECTIVES

**M.TECH. ENVIRONMENTAL SCIENCE AND TECHNOLOGY**

### SEMESTER – I

### ELECTIVE – I

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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

ES7103 UNIT OPERATIONS AND UNIT PROCESSES IN ENVIRONMENTAL TECHNOLOGY

UNIT I
Selection of unit operations and processes - Principal type of Reactors -Screening - Mixing - Coagulation and Flocculation – Flow equalization

UNIT II
Sedimentation - Type of settling - Removal ratio – Clarifier-thickener- Column flotation- air flotation.

UNIT III
Filtration – classification of filters-Head loss through filters– Darcy equation.

UNIT IV

UNIT V
Kinetics of Biological growth - Suspended and attached growth processes - Aerobic and Anaerobic - Determination of kinetic coefficients.

TOTAL : 45 PERIODS
REFERENCES

ES7104 ADVANCED NUMERICAL METHODS LTPC
3 1 0 4

OBJECTIVES
• To impart knowledge on numerical methods that will come in handy to solve numerically the problems that arise in engineering and technology. This will also serve as a precursor for future research.

UNIT I ALGEBRAIC EQUATIONS (9+3)

UNIT II ORDINARY DIFFERENTIAL EQUATIONS (9+3)
Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION (9+3)

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS (9+3)
Laplace and Poisson’s equations in a rectangular region: Five point finite difference schemes, Leibmann’s iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD (9+3)

TOTAL : 60 PERIODS

OUTCOME
It helps the students to get familiarized with the numerical methods which are necessary to solve numerically the problems that arise in engineering.
REFERENCES

ES7111 ENVIRONMENTAL ENGINEERING LAB L T P C
0 0 4 2

2. Sampling and analysis of air pollutants ambient and stacks (SPM, RPM, SO₂, NOₓ 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 I
Introduction to Air Quality; An Overview of the Clean Air Act Amendments; Fate and Transport in the Environment; Priority Air Pollutants; Indoor Air Quality. Properties of Air Pollutants; Selected Chemical and Physical Properties of Potential Atmospheric Pollutants; Basic Properties and Terminology;

UNIT II
Industrial Air Pollution Sources and Prevention; Air Pollution in the Chemical Process, Petroleum, Iron and Steel Manufacturing, Lead and Zinc Smelting Industries, Air Pollution from Nickel Ore Processing and Refining; Air Pollution from Aluminum Manufacturing; Air Pollution from Copper Smelting;

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
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

TOTAL : 45 PERIODS

REFERENCES
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

TOTAL : 45 PERIODS
REFERENCES

ES7211 SEMINAR

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

ES7301 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

ES7311  PROJECT WORK (PHASE I)  
L T P C  
0 0 12 6

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.

ES7411  PROJECT WORK (PHASE II)  
L T P C  
0 0 24 12

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.

CX7001  SOLVENT EXTRACTION  
L T P C  
3 0 0 3

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 COALESCEENCE 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 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

CX7002  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
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

CX7003 GAS TRANSPORTATION

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

CX7004 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)

CX7005 ENHANCED OIL RECOVERY

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY
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
Data Corp., 1978.

CX7006  MULTICOMPONENT DISTILLATION  L T P C
3 0 0 3

UNIT I  THERMODYNAMIC PRINCIPLES  9
Fundamental Thermodynamic principles involved in the calculation of vapor – liquid 
equilibria and enthalpies of multi component mixtures – Use of multiple equation of state 
for the calculation of K values – Estimation of the fugacity coefficients for the vapor phase 

UNIT II  THERMODYNAMIC PROPERTY EVALUATION  9
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  9
General considerations in the design of columns – Column sequencing – Heuristics for 
column sequencing – Key components – Distributed components – Non-Distributed 
components – Adjacent keys. Definition of minimum reflux ratio – calculation of Rm for 
multi component distillation – Underwood method – Colburn method.

UNIT IV  VARIOUS METHODS OF MCD COLUMN DESIGN  9
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  9
Design of sieve, bubble cap, valve trays and structured packing columns for multi 
component distillation – computation of plate efficiencies.
TEXT BOOK

CX7007 RISK ANALYSIS AND MANAGEMENT L T P C
3 0 0 3

UNIT I 9
General: Risk types, Completion, Permitting, Resource, Operating, Environmental, Manageable, Insurable, Risk Causes, Risk Analysis types and causes.

UNIT II 9

UNIT III 9
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 9

UNIT V 9

REFERENCES
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
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 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  7
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.

CX7011  ENVIRONMENTAL SCIENCE  L T P C
3 0 0 3

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

CX7012  
ENVIRONMENTAL RISK ASSESSMENT

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  INTRODUCTION  

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
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

TOTAL : 45 PERIODS

CX7015 ENVIRONMENTAL SUSTAINABILITY

UNIT I Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems 9


UNIT III Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary-Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation 9

UNIT IV Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming 9

UNIT V Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics 9

TOTAL : 45 PERIODS
REFERENCES

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

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

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

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

UNIT V
Case studies of integrated ecological engineering systems

TOTAL: 45 PERIODS

REFERENCES
UNIT III ELASTOMERS
Natural rubber, styrene-butadiene, poly isoprene-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

CX7018 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

CX7019 INDUSTRIAL POLLUTION PREVENTION L T P C 3 0 0 3

UNIT I 9
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 9
Fundamental Rights-Directive principles of state policy-Article 48(A) and 51-A (g) Judicial
enforcibility-Constitution and resources management and pollution control-Indian forest

UNIT III 9
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 9
Administrative regulation under recent legislations in water pollution control, Water
Cess Act.1977 as amended by amendment act1991.Air(prevention and control of

UNIT V 9
Relevant notifications in connection with Hazardous Wastes (Management and handling),
Biomedical Wastes (Management and Handling), Noise pollution, Eco-labelling, and EIA.

TOTAL : 45 PERIODS

27
REFERENCES

CX7020  BIOCHEMICAL ENGINEERING  L T P C
3 0 0 3

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
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

CX7022 DRUGS AND PHARMACEUTICAL TECHNOLOGY

UNIT I INTRODUCTION
Development of drugs and pharmaaceutical 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  9
Chemical conversion processes; alkylation; carboxylation; condensation and cyclisation; dehydra-
tion, 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 prac-
tice. Packing; packing techniques; quality control.

UNIT V  PHARMACEUTICAL PRODUCTS & PHARMACEUTICAL ANALYSIS  9
Vitamins; cold remedies; laxatives; analgesics; nonsteroidal contraceptives; external antiseptics;
antacids and others. Analytical methods and tests for various drugs and pharmaceuticals – spectro-
scopy, chromatography, fluorimetry, polarimetry, refractometry, pHmetry

TOTAL : 45 PERIODS

TEXT BOOK

REFERENCES
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

CX7028 ATMSHPHERIC SCIENCE
UNIT I INTRODUCTION

UNIT II ATMOSPHERIC THERMODYNAMICS

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

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

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

TOTAL : 45 PERIODS
REFERENCES

CX7029 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.

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 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
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.

REFERENCES

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

CX7035 SOIL POLLUTION ENGINEERING L T P C 3 0 0 3

UNIT I PHYSICS AND CHEMISTRY OF SOIL 8

UNIT II INORGANIC AND ORGANIC GECHEMISTRY 9

UNIT III CONTAMINANT FATE AND TRANSPORT IN SOIL 9

UNIT IV GROUND IMPROVEMENT TECHNIQUES IN WASTE MANAGEMENT 9
Role of Ground Improvement-Drainage and Ground Water Lowering-Electro osmotic Methods-Diaphragm walls-Thermal and Freezing methods - Insitu Densification - Deep
UNIT V SOIL REMEDIATION TECHNOLOGIES

TOTAL : 45 PERIODS

REFERENCES
Records and other documentation required by an organisation for health and safety. Industry specific EHS issues.

UNIT V EDUCATION AND TRAINING
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

CX7037 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
CX7038 CLIMATE CHANGE AND ADAPTATION L T P C 3 0 0 3

UNIT I EARTH’S CLIMATE SYSTEM 9

UNIT II OBSERVED CHANGES AND ITS CAUSES 9

UNIT III IMPACTS OF CLIMATE CHANGE 9

UNIT IV CLIMATE CHANGE ADAPTATION AND MITIGATION MEASURES 9

UNIT V CLEAN TECHNOLOGY AND ENERGY 9

TOTAL: 45 PERIODS

REFERENCES
2. Al core ‘inconvenient truth” – video form
3. IPCC Fourth Assessment Report – The AR4 Synthesis Report,
UNIT I  SOLID WASTE – CHARACTERISTICS AND PERSPECTIVES  
Definition - types – sources – generation and estimation. Properties: physical, chemical and biological – regulation

UNIT II  COLLECTION, TRANSPORTATION AND PROCESSING TECHNIQUES  
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  

UNIT IV  HAZARDOUS WASTE MANAGEMENT  

UNIT V  ULTIMATE DISPOSAL  

TOTAL: 45 PERIODS

TEXT BOOKS

REFERENCES

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,
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.

REFERENCES

CX7041 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.

TOTAL: 45 PERIODS

REFERENCES
REFERENCES

CX7043 PROCESS OPTIMIZATION

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

CX7044 DESIGN OF EXPERIMENTS

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, Yale’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

CX7045  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)
TEXT BOOKS

CX7024 OPERATIONS RESEARCH

<table>
<thead>
<tr>
<th>UNIT I MATHEMATICAL PROGRAMMING</th>
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<tr>
<th>UNIT II DYNAMIC PROGRAMMING</th>
<th>L T P C</th>
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<tbody>
<tr>
<td>Elements of DP models, Bellman’s optimality criteria, Recursion formula, Solution of multistage decision problem by DP method. Application is Heat Exchange Extraction systems.</td>
<td>10</td>
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</tbody>
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<table>
<thead>
<tr>
<th>UNIT III PERT, CPM and GERT</th>
<th>L T P C</th>
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<tbody>
<tr>
<td>Network representation of projects, Critical path calculation, construction of the time-chart and resource leveling, Probability and cost consideration in project scheduling, Project control. Graphical Evaluation and Review Techniques.</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>UNIT IV ELEMENTS OF QUEUING THEORY</th>
<th>L T P C</th>
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</thead>
<tbody>
<tr>
<td>Basic elements of the Queuing model, M/M/1 and M/M/C Queues.</td>
<td>7</td>
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</table>

<table>
<thead>
<tr>
<th>UNIT V ELEMENTS OF RELIABILITY THEORY</th>
<th>L T P C</th>
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</thead>
<tbody>
<tr>
<td>General failure distribution, for components, Exponential failure distributions, General model, Maintained and Non-maintained systems, Safety Analysis.</td>
<td>7</td>
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</tbody>
</table>

REFERENCES

CX7025 TOTAL QUALITY MANAGEMENT

<table>
<thead>
<tr>
<th>UNIT I CONCEPTS OF TQM</th>
<th>L T P C</th>
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</thead>
<tbody>
<tr>
<td>Philosophy of TQM, Customer focus, organization, top management commitment, team work, quality philosophies of Deming, Crosby and Muller.</td>
<td>5</td>
</tr>
</tbody>
</table>
UNIT II   TQM PROCESS  
QC Tools, Problem solving methodologies, new management tools, work habits, quality circles, benchmarking, strategic quality planning.

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

UNIT IV   QUALITY SYSTEM  
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  
Steps, KAIZEN, 5s, JIT, POKAYOKE, Taguchi methods, case studies.

TOTAL : 45 PERIODS

REFERENCES

CX7026  
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  

TOTAL : 45 PERIODS

REFERENCES

UNIT I

UNIT II

UNIT III

UNIT IV

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

TOTAL : 45 PERIODS

TEXT BOOKS

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

UNIT I  HYDROGEN – BASICS AND PRODUCTION TECHNIQUES  9
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

CX7049  FUEL CELL TECHNOLOGY

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

CX7050 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
Types of Organic Electro synthesis, Limitations in Solubility, Indirect electro synthesis, Heterogeneous Redox Catalysis, Electrosorbed hydrogen, Direct electro organic Synthesis, Examples of electro organic Synthesis. Inorganic electrochemical Process- The

TOTAL: 45 PERIODS

TEXT BOOKS

CX7051 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 BOOK

UNIT I
9

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

UNIT III
10

UNIT IV
8

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

TOTAL : 45 PERIODS

TEXT BOOKS

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

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

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

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

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

TOTAL : 45 PERIODS

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

UNIT II  THE CHLOR-ALKALI INDUSTRY  9

UNIT III  THE EXTRACTION, REFINING AND PRODUCTION OF METALS  9
Electro wining, cementation, elecro re 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 BOOK
UNIT I

UNIT II
Pollution Prevention, Pollution Prevention Concepts and Terminology, Chemical Process Safety, Responsibilities for Environmental Protection, Environmental Persistence, Classifying Environmental Risks Based on Chemical Structure, Exposure Assessment for Chemicals in the Ambient Environment.

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

REFERENCES

TOTAL : 45 PERIODS