PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To create mastery of the basic principles of engineering science that underlies modern chemical process principles used in petroleum industries.
2. To make employable process engineers in refinery fields and to work towards the development of sustainable technologies in petroleum and allied industries.
3. To address to meet the world’s ever increasing demand for hydrocarbon fuel, thermal energy and waste management.
4. To exhibit professional, ethical codes of conduct, team work and continuous learning for catering the ever changing needs of the society.

PROGRAMME OUTCOMES (POs)

On successful completion of this programme, the graduates will have the

1. Ability to apply knowledge of mathematics, Science and Engineering.
2. Ability to design a system, component, or process to meet desired needs with realistic constraints such as economical, environmental, social, ethical, health, safety, manufacturability and sustainability.
3. Ability to conduct experiments, analyze and interpret data.
4. Capacity to formulate and solve complex problems associated with refinery fields based on the realistic situation.
5. Ability to identify the impact of engineering solutions in a global, economic, and social context.
6. Ability to communicate effectively by conveying technical material through both formal written medium and also through oral presentations.
7. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practices especially in petroleum and allied industries.
8. The competency in utilizing the available resources effectively and optimally.
9. Knowledge on the importance of professional and ethical responsibilities in an organization.
10. Inclination towards acquiring knowledge on the latest developments in the field of petroleum refining and petrochemicals.

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### ANNA UNIVERSITY:: CHENNAI 600 025
AFFILIATED INSTITUTIONS
M. TECH. PETROLEUM REFINING AND PETROCHEMICALS
REGULATIONS – 2017
CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULUM AND SYLLABUS

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### Professional Core (PC)

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### Employability Enhancement Courses (EEC)

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MA5153  ADVANCED NUMERICAL METHODS  
(Common to Environmental Science and Technology, Chemical Engineering and PRPC )  
L T P C  3 2 0 4

OBJECTIVES:

- The course will develop numerical methods aided by technology to solve algebraic, transcendental and differential equations and to apply finite element methods for solving the boundary value problems in differential equations. The course will further develop problem solving skills and understanding of the application of various methods in solving engineering problems. This will also serve as a precursor for future research.

UNIT I  ALGEBRAIC EQUATIONS  
12+3


UNIT II  ORDINARY DIFFERENTIAL EQUATIONS  
12+3


UNIT III  FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS  
12+3


UNIT IV  FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS  
12+3

Laplace and Poisson’s equations in a rectangular region : Five point finite difference schemes, Leibmann’s iterative methods, Dirichlet's 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  
12+3


TOTAL : 60+15=75 PERIODS

OUTCOMES:

After completing this course, students should demonstrate competency in the following skills:

- Solve an algebraic or transcendental equation, linear system of equations and differential equations using an appropriate numerical method.
- Solving the initial boundary value problems and boundary value problems using finite difference and finite element methods.
• Selection of appropriate numerical methods to solve various types of problems in engineering and science in consideration with the minimum number of mathematical operations involved, accuracy requirements and available computational resources.

REFERENCES:


PP5101 PETROLEUM REFINERY ENGINEERING L T P C
3 0 0 3

OBJECTIVES

• To impart detailed knowledge on petroleum refining operations, this course being the last part in a three parts series.

UNIT I

Origin, Exploration and production of petroleum, Types of crudes, Composition, characteristics, products pattern and characteristics, indigenous and imported crudes, Availability Vs Demands, Future outlook.

UNIT II

Engineering aspects of refining, Reaction stoichiometry; Chemical kinetics; Thermochemistry and chemical equilibrium; Mixing in flow systems; Reactor design. Crude heating, Primary distillation, principles, Separation of cuts, Gaps/ overlaps, Stripping, Desalting, heat balance in distillation, Energy input and recovery, Vacuum distillation, Types of trays, Draw offs, intermediate product quality control.

UNIT III

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

UNIT IV

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

TOTAL: 45 PERIODS

OUTCOMES
- Students learn about the petroleum additives, support systems, and safety measures, environmental, quality and economic aspects.

REFERENCES

PP5102 PETROLEUM THERMODYNAMICS

OBJECTIVES
- To present the application of thermodynamic principles in petroleum and allied processes from chemical engineering viewpoint.

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

UNIT II CHEMICAL THERMODYNAMICS OF PETROLEUM HYDROCARBONS
Free energy change, Heat of reaction, Entropy change, Heat capacity, Heat of formation, Fugacity, Pressure – Temperature diagram, Pressure – Volume diagram, Density – Temperature diagram for one and two component system. Pressure – Composition diagram, Temperature – Composition diagram, Temperature – Composition diagram, for multi component system Gibbs phase rule

UNIT III QUALITATIVE PHASE BEHAVIOUR OF HYDROCARBON SYSTEMS
Calculation of liquid and vapour composition of Bubble point and Dew point pressure for multi component system. Equilibrium constant

UNIT IV HYDROCARBON FLUID CHARACTERISTICS
Gas formation volume factor, Gas solubility, Oil formation volume factor, Viscosity
UNIT V  PROPERTIES OF MIXTURES 9+6

TOTAL: 75 PERIODS
OUTCOME
• The Students will be well versed with the behavior of fluids under PVT conditions and also apply them for practical purpose. The study further provides a comprehensive exposition to theory and application of solution thermodynamics.

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

CX5151  CATALYTIC REACTION ENGINEERING  L T P C
3 2 0 4
OBJECTIVE:
• To impart knowledge on different types of chemical reactors, the design of chemical reactors under isothermal and non-isothermal conditions

UNIT I  CATALYST AND ITS CHARACTERIZATION 15
General definition of catalysts, Design for catalysts – Primary constituents, secondary constituents; Catalyst supports. Methods of determining catalysts activity – static methods, Study of structure pore radii; Mercury porosimetry, determination of true and apparent densities of catalysts; Structural study of electron microscopy, determination of mechanical strength of catalysts-static methods, dynamic methods; Methods of thermal analysis.

UNIT II  KINETICS OF HETEROGENEOUS CATALYTIC REACTIONS 12

UNIT III  TRANSPORT PROCESSES WITH REACTIONS CATALYZED BY SOLIDS 16
Diagnostic experimental criteria for the absence of internal and external mass transfer limitations. Nonisothermal particles.

UNIT IV CATALYST DEACTIVATION


UNIT V THE MODELING OF CHEMICAL REACTORS.


OUTCOME:

- Students would have gained knowledge on the selection of the reactor for the reaction and its design

REFERENCES


OBJECTIVES

- To impart practical knowledge on different petroleum testing methods.

LIST OF PETROLEUM TESTING EXPERIMENTS

1. Determination of flash point, fire point and Smoke point estimation
2. Viscosity, Aniline point and API gravity Determination
3. Hydrogen sulphide content determination
4. Determination of calorific value, Carbon residue determination (Conradson apparatus)
5. Bitumen testing
6. Cloud point and pour point estimation
7. Congealing point of wax
8. Foaming characteristics of lube oil and Corrosion testing of petroleum oil
9. Distillation characteristics
10. Moisture content determination
LIST OF EQUIPMENTS
One equipment in each of the following
1. Flash and fire point apparatus
2. Brookfield Viscometer
3. Aniline point apparatus
4. Specific gravity apparatus
5. Antek elemental sulphur and nitrogen analyzer
6. Bomb calorimeter
7. Ductility meter
8. Conradson apparatus
9. Cloud and pour point apparatus
10. Lubricity tester
11. Smoke point apparatus
12. Copper strip corrosion test apparatus
13. Distillation apparatus
14. Dean & Stark apparatus

OUTCOMES
- Students learn petroleum testing, determination of aniline point, softening point, carbon residue, foaming characteristics, Sulphur content etc.

PP5201 NATURAL GAS ENGINEERING

OBJECTIVES
- To know the stages of production and processing of natural gas.

UNIT I  INTRODUCTION

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

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

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

TOTAL : 45 PERIODS
OUTCOMES

- To learn origin, properties, treatment, transportation, storage and liquefaction of natural gas.

REFERENCES


PP5202 PETROCHEMICALS L T P C

OBJECTIVES

- To impart knowledge on petrochemicals used in refinery industries.

UNIT I

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

UNIT II

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

UNIT III

Petrochemical based on methane, ethylene, acetylene, propylene and butane: acetylene and methanol from methane, VCM, VAM, ethylene oxide and ethylene glycol, ethanol amides from ethylene. VCM, VAM, acrylonitrile etc. from acetylene. Isopropanol, Propylene oxide, Glycerine, acrylonitrile, Acrylic acid, etc. From propylene. Production of butadiene by dehydrogenation of butane, nitrogen.

UNIT IV

Separation and utilization of aromatics: catalytic reforming operation-seperation of BTX from Reformate .isolation of benzene, toluene, xylene. aromatics derived from thermal cracking of naptha, pyrolysis gasoline hydrogenation process. Alkylation of benzene. production of pthalic anhydride etc. synthetic detergents: classification of detergents production of KERYL Benzene Sulphonate etc., filter, binders, dyes, perfumes, etc. for detergents. Hard and soft detergents.
UNIT V
Synthetic fibres, rubbers, plastics, resins: method, mechanism and types of polymerization, production of HDPE, LDPE, PP, PVC, polystyrene, poly butadiene, etc., manufacture of polyesters, nylons, acrylic fibres, etc. production of phenol formaldehyde resin, epoxy resin, production principle of ABS plastic, polycarbonates, etc. manufacturing techniques of butyl rubber, SBR, isoprene rubber, etc.

TOTAL : 45 PERIODS

OUTCOMES
• To learn about resources, separation techniques in refining and concerned materials obtained from refining.

REFERENCES

CX5251 ADVANCED PROCESS CONTROL L T P C
3 0 0 3

OBJECTIVES
• To introduce dynamic response of open and closed loop systems, control loop components and stability of control systems along with instrumentation.

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

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

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

UNIT IV DISCRETE SYSTEMS 9

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

TOTAL: 45 PERIODS

OUTCOMES
• Students get knowledge on control strategies of process variables and digital feedback controllers for automatic process control.
REFERENCES

CX5252                  MULTICOMPONENT DISTILLATION                  L T P C
                        3 0 0  3

OBJECTIVE:
• To provide comprehensive knowledge on multicomponent distillation principle, thermodynamic property evaluation and design.

UNIT I   THERMODYNAMIC PRINCIPLES  9

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

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.

TOTAL : 45 PERIODS

OUTCOME:
• The students will understand the importance of multicomponent distillation, fundamental concepts and its applications.

REFERENCES
OBJECTIVE:
- To provide exposure to the recent developments.
- To improve the students presentation skills.

OUTCOME:
- The students will get better employability and communication skills. Students are expected to present two seminars along with report on any recent topic in Environmental Science and Technology.

OBJECTIVES
- To impart knowledge on corrosion in petroleum refining.

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

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

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

UNIT IV CORROSION IN SPECIFIC CASES AND CONTROL

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

TOTAL : 45 PERIODS

OUTCOMES
- Students learn about the types of corrosion, protection methods, corrosion in specific environments, corrosion in specific cases and control.

REFERENCE
PROJECT WORK PHASE I

OBJECTIVE:
- To apply the principles learned from various courses to solve real-time problems.

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

PROJECT WORK PHASE II

OBJECTIVE:
- To apply the principles learned from various courses to solve real-time problems.

OUTCOME:
The students will get confidence to solve challenging problems.

Phase II of Project Work is a continuation of Phase I of Project. Students submit a report at the end of Phase II.

MULTIPHASE FLOW

OBJECTIVE:
- To understand the concepts of multiphase flow and particle interaction.

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

UNIT II  PARTICLE FLUID INTERACTION

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

UNIT IV  CONSERVATION EQUATIONS
Averaging procedures - time, volume, and ensemble averaging, quasi-one-dimensional flow, two-fluid volume-averaged equations of motion, turbulence and two-way coupling.
UNIT V  MULTIPHASE SYSTEMS
Flow regime and hydrodynamic characteristics of packed bed, fluidized bed, pneumatic conveying, bubble column, trickle beds; Conventional and novel measurement techniques for multiphase systems including CARPT, Laser Doppler anemometry, Particle Image Velocimetry.

TOTAL: 45 PERIODS

OUTCOME:
• The students will understand the importance and analysis of multiphase flow.

REFERENCES

CX5072 FLUIDIZATION ENGINEERING

OBJECTIVE:
• Students gain knowledge on fundamentals of fluidization engineering, hydrodynamics, heat and mass transfer effects.

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

TOTAL : 45 PERIODS

OUTCOME:
- The students will understand the importance of fluidization engineering, solid mixing and its applications.

REFERENCES

CX5073  PIPING AND INSTRUMENTATION  L T P C
3 0 0 3

OBJECTIVES
- Students gain knowledge on fundamentals of piping engineering, pipe hydraulics, piping supports and instrumentation.

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

OUTCOME:
- Be familiar with standards, selection, support and instrumentation.
REFERENCES

PP5001 SEPARATION PROCESS TECHNIQUES
L T P C
3 0 0 3

OBJECTIVE
- To present recent advances in separation techniques from a chemical engineering viewpoint

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

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

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

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

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

TOTAL : 45 PERIODS

OUTCOMES
- To learn Liquid-solid, Gas-Solid, Liquid-Gas separation process, membrane modules, separation techniques and membrane materials.

REFERENCES

CX5074  COMPUTATIONAL FLUID DYNAMICS  LTPC
3 0 0  3

OBJECTIVE
- Be able to demonstrate competence in setting up computational fluid dynamics models for some industrially important applications. This technical competence in building and conducting CFD simulations is a skill which enhances employability.

UNIT I  CONSERVATION LAWS AND TURBULENCE MODELS  9
Governing equations of fluid flow and heat transfer—mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form. Characteristics of turbulent flows, time averaged Navier Stokes equations, turbulence models—one and two equation, Reynolds stress, LES and DNS

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

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

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

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

TOTAL: 45 PERIODS

OUTCOME:
- Students will be in a position to analyse the flow behavior in various systems.

REFERENCES
OBJECTIVES

- Student develop a sound knowledge on equilibrium in liquid-liquid system, HETS, NETS, HTU, NTU, dispersion and coalescence in extractors and design of extraction column.

UNIT I  EQUILIBRIUM IN LIQUID-LIQUID SYSTEM  9


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  13

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  14

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.

OUTCOME:

- The students will understand the fundamentals and importance of extraction processes in process industries.

REFERENCES


CX5391 PROCESS MODELING AND SIMULATION

OBJECTIVE:
- To understand the basics of model construction.
- To learn about solving model equations and validation of the models.

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

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

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

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

UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM

TOTAL : 75 PERIODS

OUTCOME:
- Understanding the fundamental of modeling and simulation, system analysis and evaluation.

REFERENCES
OBJECTIVES

- Students get the knowledge on how to measure process variables, analytical instrumentation, automatic process controls.

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

OUTCOMES

- Students get the knowledge on how to measure process variables, analytical instrumentation, automatic process controls.

REFERENCES


ES5092 DESIGN OF EXPERIMENTS

OBJECTIVE:
- To impart basic knowledge on statistical design of experiments.
- To learn about various methods employed for the 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
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
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
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
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

OUTCOME:
- The students will be in a position to solve problems involving many factors.
- Be familiar with statistical tools for environmental applications

REFERENCES
2. Douglas C. Montgomery, Design and Analysis of Experiments, John Wiley & Sons, 2005
OBJECTIVES

- Become a skilled person in HAZOP and hazard analysis and able to find out the root cause of an accident. Gain knowledge in devising safety policy and procedures to be adopted to implement total safety in a plant.

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

OUTCOME:

- Students understand that behind each fatality or serious injury there are thousands of at-risk behaviours and unidentified hazards that contributed to the incident.
- State the definition of a hazard and explain how to identify hazards in the industries/workplace.
- Determine methods for controlling hazards in the workplace.
- Complete a Job Hazard Analysis for a typical worker task.

REFERENCES

OBJECTIVES

- Students gain the knowledge on energy sources, various forms, demand, power requirements, conservation and optimization techniques and the sources of continuous power.

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

TOTAL: 45 PERIODS

OUTCOME

- The students will be in a position to develop energy efficient process
- Students will focus on the conservation of energy while developing industrial processes

REFERENCES

OBJECTIVES

- To provide a general idea about Reservoir Drive Mechanisms and also to understand the effects of production/injection on recovery of reserves.

UNIT I


UNIT II


UNIT III

Reservoir Drive Mechanisms, Natural Water Influx Reservoir, Pressure Maintenance water Flooding Performance Calculations for Stratified Reservoirs.

UNIT IV

Productivity Index, IPR. Water and Gas Coning, Decline Curve Analysis

TOTAL: 45 PERIODS

OUTCOMES

- To enable the student to interpret cross plots, flow through porous media, PVT analysis for oil, simulation and gas condensate reservoirs.

REFERENCES

2. Dake, L.P; Fundamentals of reservoir Engineering
5. Oil Reservoir Engineering S.J. Pirson
7. Towler, B. Fundamental Principles of Reservoir Engineering

OBJECTIVE

- Students should be able to design a project at the end of the course by themselves.

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

OUTCOME:
- Students will understand the significance of management information system, planning, budgeting, process plant safety and government regulations for process industries.

REFERENCES

CX5078 PROCESS OPTIMIZATION

OBJECTIVE
- Students should be able to optimize the process for a given chemical industry at the end of the course.
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

OUTCOME:
- Understanding of different objective functions and analytical methods.
- Ability to solve various multivariable optimization problems.

REFERENCES

PP5003 PETROLEUM ECONOMICS

OBJECTIVES
- To introduce process economics and industrial management principles.

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.

OUTCOMES
• Students will be able to make cost estimation, feasibility analysis, management, organization and quality control that will enable the students to perform as efficient managers.

REFERENCES
2. Cronquist, C., Estimation and classification of Reserves of Crude oil, Natural Gas, and Condensate, SPE (2001)

PP5004 NON-CONVENTIONAL PETROLEUM RESOURCES

OBJECTIVES
• Students gain knowledge on synthesizing various products from non-conventional petroleum resources.

UNIT I

UNIT II
Hydro-fracturing of coal bed methane seam. Production, installation and surface facilities. Well operation and production equipments. Treating and disposing produced water. Testing of coal bed methane wells.

UNIT III

UNIT IV
Gas hydrates accumulation in porous media. Gas extraction from gas hydrates. Uses and applications of gas hydrates.
UNIT V

OUTCOMES:
- Students will understand the recovery of various value added products from non-conventional petroleum resources.

REFERENCES
3. James T. Barts, Frank Camm, David S. Ortiz, Producing Liquid Fuels from Coal, Prospects and Policy Issues. NETL, DOE, USA, 2008,

OBJECTIVES
- After completing the course, the students will have capacity to solve, on their own hand, minor juridical questions within “Intellectual Property Rights”. They will also be able to follow and understand more complex juridical discussions.

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 PERIDOS

OUTCOMES:
- After completing the course, the students will have capacity to solve, on their own hand, minor juridical questions within “Intellectual Property Rights”. They will also be able to follow and understand more complex juridical discussions.

REFERENCES

CX5095          ENVIRONMENT, HEALTH AND SAFETY IN INDUSTRIES          L T P C
          3 0 0 3

OBJECTIVE
- To make students to get a clear picture of environment, health and safety systems, their features and techniques used and the principles and methods of effective training.

UNIT I    INTRODUCTION

UNIT II    OCCUPATIONAL HEALTH AND HYGIENE

UNIT III    WORKPLACE SAFETY AND SAFETY SYSTEMS
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
Elements of a health and safety policy and methods of its effective implementation and review. Functions and techniques of risk assessment, inspections and audits. Investigation of accidents-Principles of quality management systems in health and safety management. Relationship
between quality manuals, safety policies and written risk assessments. Records and other
documentation required by an organisation for health and safety. Industry specific EHS issues.

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

OUTCOME
- On completion of the course, the students are expected to be familiar with accident
prevention techniques, hazard analysis techniques and legislations pertaining to safety in
chemical industries.

REFERENCES
1. Effective Environmental, Health, and Safety Management Using the Team Approach by
   Bill Taylor, Culinary and Hospitality Industry Publications Services2005
2. Environmental and Health and Safety Management by Nicholas P. Cheremisinoff and
   Madelyn L. Graffia, William Andrew Inc. NY, 1995
3. The Facility Manager's Guide to Environmental Health and Safety by Brian Gallant,

CX5080  OPERATIONS RESEARCH  L T P C
3 0 0 3

OBJECTIVE
- To learn various methods of solving engineering problems using mathematical tools.

UNIT I  MATHEMATICAL PROGRAMMING  12
Introduction, Linear Programming, Solution by simplex method, Duality, Sensitivity analysis, Dual
simplex method, Integer Programming, Branch and bound method, Geometric programming and
its application.

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

UNIT III  PERT, CPM and GERT  9
Network representation of projects, Critical path calculation, construction of the timechart and
resource leveling, Probability and cost consideration in project scheduling, Project control.
Graphical Evaluation and Review Techniques.

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

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

TOTAL: 45 PERIODS
OUTCOMES:
- Understand the mathematical tools that are needed to solve optimization problems.
- Understand to use mathematical softwares to solve the proposed models.
- Understand to identify and develop operation research models for the real systems and to solve it.

REFERENCES

CX5093 PILOT PLANT AND SCALE UP METHODS L T P C
OBJECTIVE
- To impart knowledge on scale up techniques
- To understand the application of scale up of Chemical equipments

UNIT I PRINCIPALS OF SIMILARITY, PILOT PLANTS & MODELS
Introduction to scale-up methods, pilot plants and models and principles of similarity.

UNIT II DIMENSIONAL ANALYSIS AND SCALE-UP CRITERION
Dimensional analysis, regime concept, similarity criterion and scale up methods used in chemical engineering.

UNIT III SCALE-UP OF HEAT TRANSFER EQUIPMENT
Typical problems in scale-up of mixing equipment and heat transfer equipment

UNIT IV SCALE-UP OF MASS TRANSFER EQUIPMENT
Scale-up of distillation columns and packed towers for continuous and batch processes

UNIT V SCALE-UP OF CHEMICAL REACTORS
Kinetics, reactor development & scale-up techniques for chemical reactors.

TOTAL : 45 PERIODS

OUTCOME:
- Students will be in a position to design large scale plant based on pilot plant studies and scale-up methods.

REFERENCES

PP5005 ENHANCED OIL RECOVERY L T P C

OBJECTIVES
- To impart knowledge on how residual oil is recovered and the problems associated with Enhanced Oil Recovery.

UNIT I FUNDAMENTALS OF ENHANCED OIL RECOVERY 9

UNIT II WATER FLOODING 9
Properties, sampling and analysis of oil field water; Injection waters; Water flooding - Sweep efficiency, Predictive techniques, Improved water flood processes, Performance of some important water floods.

UNIT III ENHANCED OIL RECOVERY OPERATIONS-1 10
Flooding – miscible, CO2, polymer, alkaline, surfactants, steam;

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

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

TOTAL: 45 PERIODS

OUTCOMES
- Students would gain knowledge on residual oil recovery, operations and problems of Enhanced Oil Recovery.

REFERENCES

CX5082 GAS TRANSPORTATION L T P C

OBJECTIVES
- Students gain knowledge on selection of right type of transport and various types of pipes, pipeline protection techniques and design of pipeline.
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 costeffectiveness of pipelines with alternative modes of transport such as truck or railroad. Legal, safety and environmental issues about pipelines.

TOTAL: 45 PERIODS

OUTCOME:
- Students will be able to select right type of transport, pipeline protection techniques and design of pipeline.

REFERENCES

CX5083 GREEN CHEMISTRY AND ENGINEERING L T P C
3 0 0 3

OBJECTIVE
- To make students aware of global environmental issues, concepts behind pollution prevention, environmental risks, green chemistry, methods to evaluate environmental costs and life cycle assessments.

UNIT I

UNIT II

UNIT III

UNIT IV

UNIT V

OUTCOMES
- Upon completion of this course, the students would understand the fundamentals of green chemistry and engineering
- Application of these principles during the design, retrofit and management of chemical processes for a more sustainable chemical manufacturing

REFERENCES

CX5084 FUEL CELL TECHNOLOGY L T P C 3 0 0 3

OBJECTIVES
- Students gain knowledge on fuel cell principles, kinetics, in-situ and ex-situ characterization, fuel cell power plant and applications.

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

OUTCOME:
After completing the course, student should have learnt
- Basics and working principles of the Fuel cell, reaction kinetics, characterization.
- Design and stack making process for real field applications

REFERENCES