## SEMESTER I

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**TOTAL CREDITS TO BE EARNED FOR THE AWARD THE DEGREE = 66**

## LIST OF ELECTIVES

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UNIT I  ALGEBRAIC EQUATIONS 6

UNIT II  ORDINARY DIFFERENTIAL EQUATIONS – IVPS 6
Runge Kutta Methods, step size control and estimates of error, numerical stability, solution of stiff ODEs, ODE-IVPs coupled with algebraic equations;

UNIT III  ORDINARY DIFFERENTIAL EQUATIONS – BVPS 12
Finite difference method, orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method, shooting technique.

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

UNIT V  PARTIAL DIFFERENTIAL EQUATIONS – FINITE ELEMENT METHOD 9

L : 45 , T : 15 , TOTAL : 60 PERIODS

REFERENCES

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

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

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

UNIT V ANALYSIS AND DESIGN OF HETEROGENEOUS REACTORS
Isothermal and adiabatic fixed bed reactors, non-isothermal and non-adiabatic fixed bed reactors. Two-phase fluidized bed model, slurry reactor model, trickle bed reactor model. Experimental determination and evaluation of reaction kinetics for heterogeneous systems.

TOTAL: 45 PERIODS

REFERENCES

CL9112 ADVANCED TRANSPORT PHENOMENA
UNIT I BASIC CONCEPTS

UNIT II APPLICATIONS OF DIFFERENTIAL EQUATIONS OF CHANGE
Applications in laminar and Turbulent transport in compressible and incompressible fluids. Boundary layer theory.

UNIT III APPLICATIONS OF INTEGRAL EQUATIONS OF CHANGE
Macroscopic balance for isothermal and nonisothermal systems and their applications in Momentum, Heat and Mass transport problems.

UNIT IV INTERPHASE AND MULTIPHASE MOMENTUM TRANSFER

UNIT V INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS
Heat Transfer coefficient, Forced convection in tubes, around submerged objects, Heat Transfer by free convection, film type and dropwise condensation and equations for heat
transfer, Heat transfer in boiling liquids. Mass Transfer co-efficient in single and multiple phases at low and high mass transfer rates, Film theory, Penetration theory, Boundary layer theory, Macroscopic balance to solve steady and Unsteady state problems.

TOTAL : 45 PERIODS

REFERENCES

CL9113 ADVANCED THERMODYNAMICS

UNIT I BASIC CONCEPTS
Energy and first Law; Reversibility and second Law; Review of Basic Postulates, equilibrium criteria, Legendre Transformation and Maxwell’s relations

UNIT II STABILITY AND PHASE TRANSITION
Stability of thermodynamic systems, first order phase transitions and critical phenomenon, phase rule, single component phase diagrams, thermodynamic properties from volumetric and thermal data

UNIT III MULTICOMPONENT MIXTURES
Partial molar properties, fugacities in gas and liquid mixtures, activity coefficients, Ideal and Non-ideal solutions, Gibbs-Duhem equation, Wilson, NRTL, and UNIQUAC equations, UNIFAC method,

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

UNIT V CHEMICAL EQUILIBRIUM
Homogeneous gas and liquid phase reactions, heterogeneous reactions – phase and chemical equilibrium

TOTAL : 45 PERIODS

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

1. UV-Visible spectrophotometer
2. Infrared spectrophotometer
4. High performance liquid chromatograph
5. Atomic absorption spectrophotometer.
6. Flame photometer
7. Thermo gravimetric analyzer
8. Differential scanning calorimeter
9. Differential thermal analyzer

TOTAL : 30 PERIODS

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 pemeators 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, Applications, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes
UNIT V OTHER 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.

REFERENCES

TOTAL : 45 PERIODS

CL9122 ADVANCED PROCESS CONTROL L T P C
3 0 0 3

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

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

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

UNIT IV DISCRETE SYSTEMS

UNIT V DIGITAL FEEDBACK CONTROLERS

TOTAL : 45 PERIODS

REFERENCES
UNIT I  INTRODUCTION  9
The Hierarchy of Chemical process Design- Overall process Design, approaches to design.

UNIT II  CHOICE OF REACTORS AND SEPARATOR  9
Reaction path, reactor performance, practical reactors, Separation of Heterogeneous mixtures, homogeneous fluid mixtures.

UNIT III  SYNTHESIS OF REACTION – SEPARATION SYSTEMS  9
Process recycle, Batch processes, process yield

UNIT IV  DISTILLATION SEQUENCING  9
Using simple columns, using columns with more than two products, Distillation Sequencing Using thermal coupling.

UNIT V  HEAT EXCHANGER NETWORK & UTILITIES – ENERGY TARGETS  9
Heat recovery pinch, The Problem table Algorithm, Utilities Selection, Energy targets capital & total Cost targets -Number of Heat Exchanger Units, Area Targets, Number of Shells Targets, Capital Cost Targets, Total Cost Targets.

TOTAL : 45 PERIODS

REFERENCES

CL9127  SEMINAR  L T P C
0 0 2 1

Students are expected to present two seminars along with report on any recent topic in chemical engineering.
UNIT I  INTRODUCTION
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 : 45 PERIODS

REFERENCES

CL9134  PROJECT WORK (PHASE I)  L T P C
0 0 12 6
Students have to do a research-based project in the department or in an industry and submit a report at the end of Phase I

CL9141  PROJECT WORK (PHASE II)  L T P C
0 0 24 12
Phase II of Project Work is a continuation of Phase I of Project. Students submit a report at the end of Phase II.
UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS
Significance of multiphase flows, important non-dimensional numbers, parameters of characterization, calculation and measurement of particle size, size distributions and moments, size distribution models

UNIT II PARTICLE FLUID INTERACTION

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

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

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

TOTAL : 45 PERIODS

REFERENCES
CL9152  COMPUTATIONAL FLUID DYNAMICS  L T P C  3 0 0 3

UNIT I  CONSERVATION LAWS  9
Governing equations of fluid flow and heat transfer – mass conservation, momentum and energy equation, differential and integral forms, conservation and non-conservation form

UNIT II  TURBULENCE  9
Characteristics of turbulent flows, Time averaged Navier Stokes equations, Turbulence models – one and two equation, Reynolds stress, LES and DNS

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

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

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

TOTAL : 45 PERIODS

REFERENCES

CL9153  FLUIDIZATION ENGINEERING  L T P C  3 0 0 3

UNIT I  INTRODUCTION  5
The Fluidized state, Nature of hydrodynamic suspension, particle forces, species of Fluidization, Regimization of the fluidized state, operating models for fluidization systems, Applications of fluidization systems.

UNIT II  HYDRODYNAMICS OF FLUIDIZATION SYSTEMS  12
UNIT III  SOLIDS MIXING AND SEGREGATION  8
Phase juxtapositions operation shifts, Reversal points, Degree of segregation, Mixing
Segregation equilibrium, Generalised fluidization of poly disperse systems, liquid phase
Mixing and gas phase mixing.

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

REFERENCES
   1989.
2. Kwauk, M., “Fluidization - Idealized and Bubbleless, with applications”, Science

TOTAL : 45 PERIODS

CL9154  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
Techniques: General, Risk adjusted discounted rate method, Certainty Equivalent
Coefficient method, Quantitative Sensitivity analysis, Probability distribution, Coefficient
of variation method, Simulation method, Crude Procedures, Payback period, Expected
monetary value method, Refined procedures, Shackle approach, Hiller’s model, Hertz
model, Goal programming.

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
Risk Assurance and Assessment: Property Insurance, Transport insurance, Liability
insurance, Pecunious insurance, Risk Assessment, Scope Canvey study, Rijimond pilot
study, Low Probability high consequence events. Fault tree analysis, Event tree
analysis, Zero Infinity dilemma
UNIT V

TOTAL: 45 PERIODS

REFERENCES

CL9155 PROJECT ENGINEERING OF PROCESS PLANTS

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

UNIT II

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

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


TOTAL: 45 PERIODS

REFERENCES

CL9156 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
UNIT I  MATHEMATICAL PROGRAMMING  12

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

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

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

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

TOTAL : 45 PERIODS

REFERENCES

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

UNIT II  TQM PROCESS  12
QC Tools, Problem solving methodologies, new management tools, work habits, quality circles, bench marking, strategic quality planning
### UNIT III  
**TQM SYSTEMS**  
8  
Quality policy deployment, quality function deployment, Standardization, designing for quality, manufacturing for quality

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

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

**TOTAL : 45 PERIODS**

**REFERENCES**  