UNIVERSITY DEPARTMENTS
ANNA UNIVERSITY CHENNAI : : CHENNAI 600 025
REGULATIONS - 2009
CURRICULUM I TO IV SEMESTERS (FULL TIME)
M.TECH. CHEMICAL ENGINEERING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA9120	Advanced Numerical Methods	3	1	0	4
2.	CL9111	Advanced Reaction Engineering	3	0	0	3
3.	CL9112	Advanced Transport Phenomena	3	0	0	3
4.	CL9113	Advanced Thermodynamics	3	0	0	3
5.	E1	Elective I	3	0	0	3
6.	E2	Elective II	3	0	0	3
PRACTICAL						
7.	CL9116	Instrumental Methods of Analysis Lab	0	0	2	1
		TOTAL	**18**	**1**	**2**	**20**

SEMESTER II

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CL9121	Advanced Separation Processes	3	0	0	3
2.	CL9122	Advanced Process Control	3	0	0	3
3.	CL9123	Chemical Process Design	3	0	0	3
4.	E3	Elective III	3	0	0	3
5.	E4	Elective IV	3	0	0	3
6.	E5	Elective V	3	0	0	3
PRACTICAL						
7.	CL9127	Seminar	0	0	2	1
		TOTAL	**18**	**1**	**2**	**19**

SEMESTER III

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CL9131	Process Modeling and Simulation	3	0	0	3
2.	E6	Elective VI	3	0	0	3
3.	E7	Elective VII	3	0	0	3
PRACTICAL						
4.	CL9134	Project Work (Phase I)	0	0	12	6
		TOTAL	**9**	**0**	**12**	**15**

SEMESTER IV

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
PRACTICAL						
1.	CL9141	Project Work (Phase II)	0	0	24	12
		TOTAL	**0**	**0**	**24**	**12**

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

LIST OF ELECTIVES

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	CL9151	Multiphase Flow	3	0	0	3
2.	CL9152	Computational Fluid Dynamics	3	0	0	3
3.	CL9153	Fluidization Engineering	3	0	0	3
4.	CL9154	Risk Analysis and Management	3	0	0	3
5.	CL9155	Project Engineering and Process Plant	3	0	0	3
6.	CL9156	Process Optimization	3	0	0	3
7.	CL9157	Operations Research	3	0	0	3
8.	CL9158	Total Quality Management	3	0	0	3

MA9120 ADVANCED NUMERICAL METHODS L T P C
3 1 0 4

UNIT I ALGEBRAIC EQUATIONS 6

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

UNIT II ORDINARY DIFFERENTIAL EQUATIONS – IVPS 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

Partial differential equations – Finite element method - orthogonal collocation method, orthogonal collocation with finite element method, Galerkin finite element method.

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

REFERENCES

1. Gupta, S.K., Numerical Methods for Engineers, New Age Publishers, 1995
2. Jain, M. K., S. R. Iyengar, M. B. Kanchi, R. K. Jain, Computational Methods for Partial Differential Equations, New Age Publishers, 1993.

CL9111 ADVANCED REACTION ENGINEERING L T P C
3 0 0 3

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 9

Catalyst properties – Adsorption Isotherms – Surface reactors – Desorption – Rate limiting steps – Is adsorption of Cumene rate limiting – Cumene decomposition – Chemical vapour deposition catalyst deactivation – reaction engineering in microelectronic device fabrication.

UNIT IV INTERNAL TRANSPORT PROCESSES IN POROUS CATALYSTS 9

Interpellet mass and heat transfer, evaluation of effectiveness factor, mass and heat transfer with reaction.

UNIT V ANALYSIS AND DESIGN OF HETEROGENEOUS REACTORS 9

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

1. Carberry, J. J., "Chemical and Catalytic Reaction Engineering", Dover Publications, 2001.
2. Froment, G. F. and Bischoff, K. B., "Chemical Reactor Design and Analysis", 2nd Edition, John Wiley & Sons, New York, 1997.

CL9112 ADVANCED TRANSPORT PHENOMENA L T P C

3 0 0 3

UNIT I BASIC CONCEPTS 9

Phenomenological Equations and Transport properties, Rheological behaviour of fluids, Balance Equations – Differential and Integral equations.

UNIT II APPLICATIONS OF DIFFERENTIAL EQUATIONS OF CHANGE 9

Applications in laminar and Turbulent transport in compressible and incompressible fluids. Boundary layer theory.

UNIT III APPLICATIONS OF INTEGRAL EQUATIONS OF CHANGE 9

Macroscopic balance for isothemal and nonisothermal systems and their applications in Momentum, Heat and Mass transport problems.

UNIT IV INTERPHASE AND MULTIPHASE MOMENTUM TRANSFER 9

Friction factor, Fluid –Fluid systems, Flow patterns in vertical and horizontal pipes, Formulation of bubbles and drops and their size distribution, Solid – fluid systems, Forces acting on stagnant and moving solids, Flow through porous medium, Capillary tube model and its applications.

UNIT V INTERPHASE TRANSPORT IN NON-ISOTHERMAL SYSTEMS 9

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

1. Bird R.B., Stewart, W. E. and Lightfoot, E. N., "Transport Phenomena", 2nd Edn., John Wiley and Sons, 2002.
2. Welty, J.R., Wicks, C. E. and Wilson, R. E., "Fundamentals of Momentum, Heat Mass Transfer", 5th Edn., John Wiley and Sons, 2007.
3. Brodkey, R. S. and Hershey, H. C., "Transport Phenomena – A Unified Approach", Brodkey Publishing, 2003.

CL9113 ADVANCED THERMODYNAMICS L T P C
3 0 0 3

UNIT I BASIC CONCEPTS 9

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 9

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 9

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 9

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 9

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
2. Tester, J. W. and M. Modell, Thermodynamics and Its Applications. 3rd Edn. Prentice Hall, New Jersey, 1997.
3. Prausnitz, J.M., Lichtenthaler R.M. and Azevedo, E.G., Molecular thermodynamics of fluid-phase Equilibria, 3rd Edn, Prentice Hall Inc., New Jersey, 1999

CL9116 INSTRUMENTAL METHODS OF ANALYSIS LAB L T P C
0 0 2 1

LIST OF EXPERIMENTS

1. UV-Visible spectrophotometer
2. Infrared spectrophotometer
3. Gas chromatograph.
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

CL9121 ADVANCED SEPARATION PROCESSES L T P C
3 0 0 3

UNIT I GENERAL 12

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 8

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 8

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 8

Controlling factors, Applications, Types of equipment employed for electrophoresis, dielectrophoresis, Ion Exchange chromatography and electrodialysis, Commercial processes

UNIT V OTHER TECHNIQUES 9

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

TOTAL : 45 PERIODS

REFERENCES

1. King, C. J., "Separation Processes", Tata McGraw Hill Co., Ltd., 1982.
2. Nakagawal, O. V., "Membrane Science and Technology", Marcel Dekker, 1992.
3. Rousseau, R. W., "Handbook of Separation Process Technology", John Wiley, New York, 1987.
4. Humphrey, J and G. Keller, Separation Process Technology, McGraw-Hill, 1997

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

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

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

Z – Transform and inverse Z – transform properties, Discrete – Time Response of dynamic system, Pulse Transfer Function, Closed Loop System Stability.

UNIT V DIGITAL FEEDBACK CONTROLLERS 9

Design of digital feedback controllers, digital approximation of classical, effect of sampling, Dahlin's algorithms, Dead – beat algorithm, ringing, IMC algorithm, simplified model predictive algorithm.

TOTAL : 45 PERIODS

REFERENCES

1. Bequette, B. W., Process Control: Modeling, Design, and Simulation, Prentice Hall, 2003
2. Stephanopolous, G., "Chemical Process Control", Prentice Hall of India, New Delhi, 1985.

CL9123 CHEMICAL PROCESS DESIGN L T P C
3 0 0 3

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

1. Smith, R., “Chemical Process Design”, McGraw Hill, New York, 1995.
2. Douglas, J.M., “Conceptual Design of Chemical Process”, McGraw Hill, New York, 1988.

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.

CL9131 PROCESS MODELLING AND SIMULATION L T P C
3 0 0 3

UNIT I INTRODUCTION 5

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

UNIT II STEADY STATE LUMPED SYSTEMS 9

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 9

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 9

Analysis of compressible flow, heat exchanger, packed columns, plug flow reactor, solution of ODE boundary value problems.

UNIT V UNSTEADY STATE DISTRIBUTED SYSTEM 13

Analysis laminar flow in pipe, sedimentation, boundary layer flow, conduction, heat exchanger, heat transfer in packed bed, diffusion, packed bed adsorption, plug flow reactor, hierarchy in model development, classification and solution of partial differential equations - Empirical modeling, parameter estimation, population balance and stochastic modeling.

TOTAL : 45 PERIODS

REFERENCES

1. Ramirez, W., "Computational Methods in Process Simulation", 2nd Edn., Butterworths, New York, 2000.
2. Luyben, W.L., "Process Modelling Simulation and Control", McGraw-Hill Book Co., 1973.
3. Felder, R. M. and Rousseau, R. W., “Elementary Principles of Chemical Processes“, John Wiley, 2000.
4. Franks, R. G. E., “Mathematical Modelling in Chemical Engineering“, John Wiley, 1967.

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.

CL9151 MULTIPHASE FLOW L T P C
3 0 0 3

UNIT I CHARACTERISTICS OF MULTIPHASE FLOWS 9

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 9

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, effects of acceleration, effects of coupling; Interaction between particles – mechanisms of interaction, interparticle forces, hard sphere model, soft sphere model, discrete element modeling, semi-empirical methods, kinetic theory, force chains.

UNIT III MODELLING OF MULTIPHASE FLOWS 9

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 9

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 9

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

1. Clift, R., Weber, M.E. and Grace, J.R., Bubbles, Drops, and Particles, Academic Press, New York, 1978.
2. Crowe, C. T., Sommerfeld, M. and Tsuji, Y., Multiphase Flows with Droplets and Particles, CRC Press, 1998
3. Fan, L. S. and Zhu, C., Principles of Gas-solid Flows, Cambridge University Press, 1998
4. Govier, G. W. and Aziz. K., “The Flow of Complex Mixture in Pipes”, Van Nostrand Reinhold, New York, 1972.
5. Kleinstreuer, C., Two-phase Flow: Theory and Applications, Taylor & Francis, 2003
6. Rhodes, M., Introduction to Particle Technology, John Wiley & Sons, New York. 1998.
7. Wallis, G.B., “One Dimensional Two Phase Flow”, McGraw Hill Book Co., New York, 1969.

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

1. Anderson, J. D., “Computational Fluid Dynamics: The Basics with Applications”, McGraw-Hill, 1995.
2. Fletcher, C. A. J., “Computational Techniques for Fluid Dynamics”, Springer Verlag, 1997.
3. Versteeg, H.K. and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The Finite Volume Method”, Pearson Education Ltd., 2007.

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

General bed behaviour, pressure drop, Flow regimes, Incipient Fluidization, Pressure fluctuations, Phase Holdups, Measurements Techniques, Empirical Correlations for Solids holdup, liquid holdup and gas holdup. Flow models – generalized wake model, structural wake model and other important models.

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, 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

REFERENCES

1. Fan, L. S., "Gas- liquid Solid Fluidization Engineering", Butterworths, 1989,
2. Kwauk, M., "Fluidization - Idealized and Bubbleless, with applications", Science Press, 1992.
3. Kunii, D. and Levenspiel, O., "Fluidization Engineering", 2nd Edn., Butterworth-Heinemann, London, 1991.

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 **9**

Risk Analysis in Chemical Industries : Handling and storage of Chemicals, Process plants, Personnel protection equipments. Environmental risk analysis, International environmental management system, Corporate management system, Environmental risk assessment, Total quality management, Paradigms and its convergence.

TOTAL : 45 PERIODS

REFERENCES

1. Srivastav, S., "Industrial Maintenance Management", Sultan Chand & Co., 1998.
2. Rao, P. C. K., "Project Management and Control", Sultan Chand & Co., Ltd., 1996
3. Sincero, A. P. and Sincero, G. A., "Environmental Engineering – A Design Approach", Prentice Hall of India, 1996.
4. Pandya, C. G., "Risks in Chemical Units", Oxford and IBH Publishers, 1992.
5. Fawcett, H. H., "Safety and Accident Prevention in Chemical Operations by John Wiley & Sons, 1982.
6. Kind, R. W., "Industrial Hazard and Safety Handbook" Butterworth, 1982.
7. Steiner, H. M., "Engineering Economic Principles", McGraw Hill Book Co., New York, 1996.

CL9155 PROJECT ENGINEERING OF PROCESS PLANTS **L T P C**

3 0 0 3

UNIT I **9**

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

UNIT II **9**

Planning the process, Strategic and Managerial Planning, Organising the process planning, cost and costing, Cost Control systems, Economic Balancing, Network Planning, Methods (PERT/CPM), Engineering Flow Diagrams, Cost requirements, Analysis and Estimation of Process Feasibilities (Technical/Economical) Analysis, Cost – Benefit Ratio Analysis, Project Budgeting, Capital Requirements, capital Market, Cash Flow Analysis, Break even strategies.

UNIT III **9**

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 **9**

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 **9**

Government regulations on procurement of raw materials and its allocation. Export – Import regulations, Pricing policy, Industrial licensing procedure, Excise and other commercial taxes, Policies on depreciation and corporate tax, Labour laws, Social welfare legal measurements, Factory act, Regulations of Pollution Control Board.

TOTAL : 45 PERIODS

REFERENCES

1. Cheremisinoff, N. P., Practical Guide to Industrial Safety: Methods for Process Safety Professionals, CRC Press, 2001
2. Couper, J. R., Process Engineering Economics, CRC Press, 2003.
3. Perry, J. H. "Chemical Engineer's Hand Book", 8th Ed., McGraw Hill, New York, 2007.
4. Peters, M. S., Timmerhaus, C. D. and West, R. E., "Plant Design and Economics for Chemical Engineers", 5th Edn., McGraw Hill, 2003.
5. Silla, H., Chemical Process Engineering: Design and Economics, CRC Press, 2003
6. Vinoski, W., Plant Management Handbook, Pearson Education, Limited, 1998
7. Watermeyer, P., Handbook for Process Plant Project Engineers, John Wiley and Sons, 2002

CL9156 PROCESS OPTIMIZATION L T P C
3 0 0 3

UNIT I INTRODUCTION **5**

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

UNIT II LINEAR PROGRAMMING **10**

Simplex method, Barrier method, sensitivity analysis, Examples.

UNIT III NONLINEAR UNCONSTRAINED OPTIMIZATION **10**

Convex and concave functions unconstrained NLP, Newton's method Quasi-Newton's method, Examples.

UNIT IV CONSTRAINED OPTIMIZATION **10**

Direct substitution, Quadratic programming, Penalty Barrier Augmented Lagrangian Methods.

UNIT V MULTI OBJECTIVE OPTIMIZATION **10**

Weighted Sum of Squares method, Epsilon constrain method, Goal attainment Examples. Introduction to optimal control and dynamic optimization.

TOTAL : 45 PERIODS

REFERENCES

1. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
2. Diwaker, U. W. "Introduction to Applied Optimization", Kluwer, 2003.
3. Joshi, M. C. and Moudgalya, K. M., "Optimization, Theory and Practice", Narosa, New Delhi, 2004.
4. Rao, S. S., Engineering Optimization: Theory and Practice, New Age Publishers, 2000

CL9157 OPERATIONS RESEARCH L T P C
3 0 0 3

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 time-chart and resource leveling, Probability and cost consideration in project scheduling, Project control. Graphical Evaluation and Review Techiques.

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

1. Carter, M. W. and Price, C. C., Operations Research: A Practical Introduction Contributor, CRC Press, 2001
2. Edgar, T. F., Himmelblau, D. M. and Ladson, L. S., "Optimization of Chemical Processes", 2nd Ed., McGraw Hill, New York, 2003.
3. Hillier, F. S., and Lieberman, G. J., Introduction to Operations Research, McGraw-Hill, 2005
4. Taha, H. A., "Operations Research, An introduction", 6th Ed., Prentice Hall of India, New Delhi, 1997.

CL9158 TOTAL QUALITY MANAGEMENT L T P C
3 0 0 3

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

1. Rose J. E., “Total quality Management”, Kogan Page Ltd, 1993.
2. Bank, J., “The essence of Total Quality Management”, Prentice Hall of India, 1993.
3. Bonds, G., “Beyond Total Quality Management”, McGraw Hill, 1994.
4. Osada, T., “The 5S’s, The Asian Productivity Organisation”, 1991.