

AFFILIATED INSTITUTIONS
ANNA UNIVERSITY, CHENNAI
REGULATIONS - 2009
CURRICULUM I SEMESTER (FULL TIME)
M.TECH. CHEMICAL ENGINEERING

SEMESTER I

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	MA9333	Advanced Numerical Methods	3	1	0	4
2.	CH9311	Advanced Reaction Engineering	3	0	0	3
3.	CH9312	Advanced Transport Phenomena	3	0	0	3
4.	CH9313	Advanced Thermodynamics	3	0	0	3
5.	E1	Elective I	3	0	0	3
6.	E2	Elective II	3	0	0	3
PRACTICAL						
7.	CH9316	Instrumental Methods of Analysis Lab	0	0	2	1
TOTAL			18	1	2	20

LIST OF ELECTIVES

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	CH9001	Multiphase Flow	3	0	0	3
2.	CH9002	Computational Fluid Dynamics	3	0	0	3
3.	CH9003	Fluidization Engineering	3	0	0	3
4.	CH9004	Risk Analysis and Management	3	0	0	3
5.	CH9005	Project Engineering and Process Plant	3	0	0	3
6.	CH9006	Process Optimization	3	0	0	3
7.	CH9007	Operations Research	3	0	0	3
8.	CH9008	Total Quality Management	3	0	0	3

MA9333

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.

CH9311

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.

**CH9312 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 isothermal 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.

**CH9313 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/VLE

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

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

CH9001

MULTIPHASE FLOWL 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

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.

CH9005 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

CH9006	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.		

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.

CH9008	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.