SCHEME

OF

STUDIES AND EXAMINATIONS

M.Tech. (Chemical Engineering)
w.e.f. 2009-2010

Department of Chemical Engineering

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY
MURTHAL (SONEPAT)

SCHEME OF STUDIES & EXAMINATIONS
M. Tech. 1st YEAR (SEMESTER – I) (CHEMICAL ENGINEERING)
Credit Based Scheme w.e.f. 2009-10

S. No.	Course No.	Course Title	Teaching Schedule			Marks of Class work	Examination Marks		Total	Credit	Duration of Exam
			L	P	Total		Theory	Practical			
1	CHE-501	MODELING AND SIMULATION	4	-	4	50	100	-	150	4	3
2	CHE-503	ADVANCED TRANSPORT PHENOMENA	4	-	4	50	100	-	150	4	3
3	CHE-505	ADVANCED THERMODYNAMICS	4	-	4	50	100	-	150	4	3
4	CHE-507	APPLIED MATHEMATICS IN CHEMICAL ENGINEERING	4	-	4	50	100	-	150	4	3
5	CHE-509	ADVANCED CHEMICAL REACTION ENGG.	4	-	4	50	100	-	150	4	3
6	CHE-511	MODELING AND SIMULATION LAB	-	3	3	50	-	50	100	3	3
TOTAL			**20**	**3**	**23**	**300**	**500**	**50**	**850**	**23**	

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY, MURTHAL (SONEPAT)
SCHEME OF STUDIES & EXAMINATIONS
M. Tech. 1st YEAR (SEMESTER – II) (CHEMICAL ENGINEERING)
Credit Based Scheme w.e.f. 2009-10

S. No.	Course No.	Course Title	Teaching Schedule			Marks of Class work	Examination Marks		Total	Credit	Duration of Exam
			L	P	Total		Theory	Practical			
1	CHE-502	ADVANCED PROCESS DYNAMICS AND CONTROL	4	-	4	50	100	-	150	4	3
2	CHE-504	ADVANCED SEPARATION PROCESSES	4	-	4	50	100	-	150	4	3
3	CHE-506	ADVANCED HEAT TRANSFER	4	-	4	50	100	-	150	4	3
4	CHE-	ELECTIVE-I	4	-	4	50	100	-	150	4	3
5	CHE-	ELECTIVE-II	4	-	4	50	100	-	150	4	3
6	CHE-512	PROCESS DYNAMICS AND CONTROL LAB	-	3	3	50	-	50	100	3	3
7	CHE-514	SEMINAR - I	-	2	2	50	-	-	50	2	-
TOTAL			**20**	**5**	**25**	**350**	**500**	**50**	**900**	**25**	

Elective-I:
1. CHE-554: PETROLEUM ENGINEERING
2. CHE-556: FLUIDIZATION ENGINEERING.

Elective-II:
1. CHE-560: CHEMICAL PROCESS INTEGRATION
2. CHE-562: RENEWABLE ENERGY TECHNOLOGIES.

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY, MURTHAL (SONEPAT)
SCHEME OF STUDIES & EXAMINATIONS
M. Tech. 2nd YEAR (SEMESTER – III) (CHEMICAL ENGINEERING)
Credit Based Scheme w.e.f. 2010-11

S. No.	Course No.	Course Title	Teaching Schedule			Marks of Class work	Examination Marks		Total	Credit	Duration of Exam
			L	P	Total		Theory	Practical			
1	CHE-601	OPTIMIZATION OF CHEMICAL PROCESSES	4	-	4	50	100	-	150	4	3
2	CHE-603	ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT	4	-	4	50	100	-	150	4	3
3	CHE-605	DISSERTATION(PHASE-I)	-	4	4	100	-	-	100	4	-
4	CHE-	ELECTIVE III	4	-	4	50	100	-	150	4	3
5	CHE-609	ENVIRONMENTAL ENGG. LAB	-	3	3	50	-	50	100	3	3
6	CHE-611	SEMINAR - II	-	2	2	50	-	-	50	2	-
TOTAL			**12**	**9**	**21**	**350**	**300**	**50**	**700**	**21**	

Elective-III:
1. CHE-651: POLYMER SCIENCE AND ENGINEERING
2. CHE-653: FUEL CELL TECHNOLOGIES.
3. CHE-655: INDUSTRIAL RISK AND SAFETY MANAGEMENT.

DEENBANDHU CHHOTU RAM UNIVERSITY OF SCIENCE & TECHNOLOGY, MURTHAL (SONEPAT)
SCHEME OF STUDIES & EXAMINATIONS
M. Tech. 2nd YEAR (SEMESTER – IV) (CHEMICAL ENGINEERING)
Credit Based Scheme w.e.f. 2010-11

S. No.	Course No.	Course Title	Teaching Schedule			Marks of Class work	Examination Marks		Total	Credit	Duration of Exam
			L	P	Total		Theory	Practical			
1	CHE-602	DISSERTATION	-	25	25	250	-	500	750	25	3
TOTAL			**-**	**25**	**25**	**250**	**-**	**500**	**750**	**25**	

SYLLABUS

CHE – 501 : MODELING AND SIMULATION

M. Tech. Semester - I (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction: Models and Model building. Use of Mathematical Models

UNIT-II: Modeling Fundamentals: Principles of formulation, Fundamental laws, Model characteristics, Development of mass, energy and momentum balance-equations; Lumped parameter models (steady-state and unsteady state)
Distribution parameter models (steady-state and unsteady state) Stochastic models-discrete state/continuous state.

UNIT-III: Mathematical Models in Chemical Engineering: Development of models, solution of linear and non-linear equations, Development of models for surge tanks, continuous stirred tank reactors (CSTR) with and without heating jacket, Isothermal and non-isothermal systems. Single and Multi-component vaporizers.

UNIT-IV: Reaction systems: Batch reactor, Reactor with mass transfer, Ideal and non-ideal binary Distillation Column, Batch Distillation with hold up, pH systems. Development of models for multistage processes, adsorption column, extraction, heat exchangers and evaporators.

UNIT-V: Simulation Case studies for simulation and Simulation examples. Numerical and software simulation techniques.

TEXT / REFERENCE BOOKS:

1. W.F.Ramirez, Computational Methods In Process Simulation, Butterworth, 1989.
2. R.E.Franks, Modeling and Simulation in Chemical Engineering, John Wiley, 1972
3. W.L.Luyben, Process Modeling, Simulation and Control for Chemical Engineers, Mcgraw-Hill (1990)

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 503 : ADVANCED TRANSPORT PHENOMENA

M. Tech. Semester - I (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Momentum mass and energy balance equations; Equations of change for isothermal systems; Velocity distributions in flow systems; Interphase transport in isothermal Systems; Microscopic and macroscopic balance.

UNIT-II: Theories of turbulence- phenomenological and statistical; Turbulent transfer processes in single and multiphase systems; Temperature distribution in turbulent flow; Concentration fluctuation and time smoothed concentration; Turbulent mixing with first and second order reactions.

UNIT-III: Boundary layer theory; Steady state transport in boundary layers; Taylor dispersion in laminar tube flow.

UNIT-IV: Interphase transport in non-isothermal systems. Equation of change for entropy; Application of generalized Maxwell – Stephan's equations; Mass transport across selectively permeable membrane and porous media.

TEXT / REFERENCE BOOKS:

1. Transport Phenomena, Bird R. Byron, Stewart, Warren E., Lightfoot, Edwin N., 2nd Edition, John Wiley & Sons, 2001.
2. Transport Phenomena – A unified Approach, R. S. Brodkey & H. C. Hershey, McGraw Hill.
3. Transport Processes & Unit Operations, C. J. Geankoplis, PHI, New Delhi.
4. W.M. Dean-Analysis of Transport Phenomena, Oxford University Press, New York, 1998.
5. Advanced Transport Phenomenon, by Slattery, J.C. , Cambridge University Press, 1999.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 505 : ADVANCED THERMODYNAMICS

M. Tech. Semester - I (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction: Heat capacity, First law of thermodynamics, Enthalpy, Thermodynamic processes, Flow processes, Phase rule, PVT behavior of pure substances, Virial equations, Heat effects.

UNIT-II: Second Law of Thermodynamics: Heat engine, Carnot cycle, Entropy, Entropy changes of an ideal gas, Refrigeration, Refrigeration cycles, Choice of refrigerant, Heat pump, Liquefaction processes.

UNIT-III: Thermodynamic Properties of Fluids: Fundamental property relations, Maxwell's equations, Residual properties, Clapeyron's Equation, Generalized correlations for thermodynamic properties of gases.

UNIT-IV: Multi-component Systems: Chemical potential, Ideal-gas mixture, Ideal solution, Raoult's law, Partial properties, Fugacity and fugacity coefficient, Generalized correlations for the fugacity coefficient, Excess Gibbs' energy, Activity coefficient.

UNIT-V: Phase Equilibria at Low to Moderate Pressures: Phase rule, Phase behavior for vapor liquid system, Margules equation, Van Laar equation, Wilson equation, NRTL equation. Dew point, Bubble point and flash calculations.

UNIT-VI: Solution Thermodynamics: Ideal salutation, Fundamental residual-property relation, Fundamental excess-property relation, Evaluation of partial properties. Heat effects of mixing processes. Partially miscible systems.

UNIT-VII: Chemical Reaction Equilibria: Reaction coordinate, Equilibrium criteria to chemical reactions, Standard Gibbs' energy change and the equilibrium constant. Effect of temperature on the equilibrium constant, Evaluation of equilibrium constants. Relations between equilibrium constants and compositions; Gas-phase reactions, Liquid-phase reactions, Calculations of equilibrium compositions for single-phase reactions, Multi reaction equilibria.

UNIT-VIII: Statistical Thermodynamics: Postulates, Macro states and microstates, Partition Function, Maxwell - Boltzmann, Bose-Einstein and Fermi-Dirac statistics. Applications of Statistical Thermodynamics: Ideal gas, Maxwell speed distribution, Einstein & Debye Models of a solid.

TEXT / REFERENCE BOOKS:

1. Smith, J.M., Van, Ness, H.C. and Abbott, M.M. "Introduction to Chemical Engineering Thermodynamics", 6th Ed., McGraw-Hill, 2001.
2. Rao, Y.V.C., "Chemical Engineering, Thermodynamics," University Press, 1997.
3. Rao, Y.V.C., "An Introduction to Thermodynamics," John Wiley, 1993.
4. Kyle, B.G., "Chemical and Process Thermodynamics," 3rd ed., PHI, New Delhi

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 507 : APPLIED MATHEMATICS IN CHEMICAL ENGINEERING

M. Tech. Semester - I (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction to numerical computations in chemical engineering**:** General introduction to the subject of numerical analysis, Representing numbers, Polynomial curve fit by least squares method and its application to chemical processes. Newton's divided difference interpolation, Forward differences with equally space base points, Bisection method for one variable, Fixed point iteration for one variable, Newton's method for one variable, Secant method for one variable, Regula Falsi for one variable.

UNIT-II: Linear equations: Solution of linear system by Gaussian elimination with backward substitution, The Gauss-Jordan modification (method), Iterative solution for linear systems, Iterative refinement for linear systems, Jacobi iterative method for linear systems, Gauss-Seidel iterative technique for linear systems, Convergence for the Jacobi method.

UNIT-III: Nonlinear equations: Fixed point iteration for non-linear systems, Newton's method for non-linear systems, Evaluation of the Jacobian, Steepest decent techniques for non-linear systems.

UNIT-IV: Numerical solutions of ordinary differential: Initial value problems: single step methods, multi-step methods; boundary value problems - solution procedure by finite difference scheme.

UNIT-V: Numerical solutions of partial differential equations: Numerical solution of partial differential equations; classification of PDE's; finite difference methods for solution of parabolic, elliptic and hyperbolic PDE's. Introduction to finite element methods: Variation principle approach; weighted residual methods.

TEXT / REFERENCE BOOKS:

1. Kahaner, Moler and Nash "Numerical Methods and Software." Prentice Hall. (1989).
2. Hanna and Sandall "Computational Methods in Chemical Engineering. Prentice Hall. (1995).
3. Burden, R. L., Faires J. D. "Numerical Analysis" 5th edition.
4. Carnahan B, Luther, H. A, Wilkes J. O. "Applied Numerical Methods"
5. S.K. Gupta, Appl. Maths. In Chem. Engg.
6. Mickley Sherwood and Read "Applied Mathematics in Chemical Engineering" McGraw Hill Series in Chemical Engineering.
7. Ross and Taylor, Applied Mathematics.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 509 : ADVANCED CHEMICAL REACTION ENGINEERING

M. Tech. Semester - I (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Kinetics of Heterogeneous Reactions - Catalytic Reactions, Rate controlling steps, Langmuir-Hinshelwood kinetics, Rideal-Eiley Mechanism, Non catalytic fluid-solid reaction- Shrinking and Unreacted Core Model.

UNIT-II: Non-Ideal Flow-Residence Time Distribution, Dispersion Model, Tanks-in-Series Model, Mixing concepts, Segregated Flow Model.

UNIT-III: External Diffusion Effects in Heterogeneous Reactions Mass and Heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects. Modeling diffusion with and without reaction.

UNIT-IV: Internal Transport Processes in Porous Catalysts -Intra pellet mass and heat transfer, Evaluation of effectiveness factor, Mass and Heat transfer with reaction.

UNIT-V: Design of Heterogeneous Catalytic 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.

TEXT / REFERENCE BOOKS:

1. Chemical Engineering Kinetics, J. M. Smith-McGrawHill
2. Elements of Chemical Reaction Engineering, H. Scott Fogler-PHI
3. Chemical Reaction Engineering, O. Levenspiel -Willey Student Edition

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 511 : MODELING AND SIMULATION LAB

M. Tech. Semester - I (Chemical Engineering)

L	P	Credits			
--	3	3	Class Work	:	50 Marks
			Examination	:	50 Marks
			Total	:	100 Marks
			Duration of Examination	:	3 Hours

Modeling and Simulation of Chemical Engineering Systems like:

1. Stirred tanks with/without heating jackets
2. Reaction systems
3. CSTR's isothermal and non-isothermal
4. Flash calculations
5. Multi-component distillation column
6. Batch distillation with constant and variable reflux
7. Batch distillation with holdup
8. Multistage absorption
9. Multistage adsorption
10. Extraction and leaching

Software such as Aspen Plus/Chem-CAD, MATLAB, C++ etc. may be used in modeling above problems.

CHE – 502 : ADVANCED PROCESS DYNAMICS AND CONTROL

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Closed-Loop Systems-First and Higher order systems, response to various inputs. Linear Closed-Loop Systems. Controllers and Final Control Elements. Control Valve – Valve Sizing, Valve Characteristics

UNIT-II: Stability and Frequency response-Routh Hurwitz method, Root locus method, Frequency response, design of control system, Zigler-Nichols and Cohen-Coon tuning methods, Bode diagrams, Bode stability criterion, Nyquist plots.

UNIT-III: Advanced Control Systems-Feedback- control of systems with Large Dead Time, Feed-forward and Ratio Control, Adaptive and Inferential Control Systems, Internal Model Control.

UNIT-IV: Multi-loop and Multivariable Control-Control Loop Interactions, Bristol's Relative Gain Array Method, Singular Value Analysis, Tuning of Multi-loop PID Control system, Decoupling Control.

UNIT-V: Model Predictive Control-Overview, Predictions for SISO/MIMO Models, MPC calculations, Selection of Design and Tuning Parameters, Implementation of MPC.

UNIT-VI: Digital Sampling, Filtering, and Control-Sampling and Signal Reconstruction, Signal Processing and Data Filtering, z-Tranform Analysis for Digital Control, Tuning of PID Controllers.

TEXT / REFERENCE BOOKS:

1. Process Systems Analysis and Control, D. R. Coughanour-McGrawHill
2. Chemical Process Control, G. Stephanopoulos-PHI
3. Process Dynamics and Control, Seborg D. E., Edgar T. F., Mellichamp D. A.-John Willey and Sons

NOTE : Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 504 : ADVANCED SEPARATION PROCESSES

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Membrane separation-Characterization of membranes; transport through porous and non-porous membranes; reverse osmosis, electro dialysis, gas permeation; pervaporation, concentration, pressure, electrically and thermally driven membrane processes; membrane reactors; polarization; fouling; modules; energy requirements.

UNIT-II: Adsorptive separation-Definition; types of adsorption; adsorbent types, their preparation and properties; adsorption isotherms and their importance; equipment types for commercial processes; mathematical modeling with suitable initial and boundary conditions for different cases such as thermal swing, pressure swing and moving bed adsorption; chromatography.

UNIT-III: Other techniques-Reactive distillation; supercritical fluid extraction; surfactant based separations; cryogenic separation; ionic separation.

TEXT / REFERENCE BOOKS:

1. Basic principles of Membrane Technology by Marcel Mulder; Kluwer Academic Publishers, Boston/London.
2. Membrane Handbook by W S Ho, K K Sirkar; Kluwer.
3. Reverse Osmosis & Ultra-Filtration Process Principles by S Sourirajan, T Matsuura; NRC Publication NO.24188, Ottawa, 1985.
4. Handbook of Separation Process Technology by Ronald W Roussel; John Wiley, New York.
5. Principles of Adsorption & Adsorption Processess by D M Ruthven; John Wiley.
6. Large Scale Adsorption & Chromatography by D M Ruthven; CRC, 1986.
7. Supercritical Fluid Extraction by M A McHugh, V J Krukonis; Butterworth.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than three) is to be set from each unit.

CHE – 506 : ADVANCED HEAT TRANSFER

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT–I: Analysis of convective heat transfer-Convective heat transfer, boundary layer fundamentals, conservation of mass, momentum & energy for laminar & flow over a flat plate, boundary layer equations & similarity parameters, dimensional analysis, integral equations of the laminar boundary layer, analysis between momentum & heat transfer over a flat surface; turbulent flow & turbulent boundary layers analysis, analysis for turbulent flow over a flat surface.

UNIT–II: Heat transfer by natural convection-Temperature a velocity distribution in thermal boundary layers, governing equations of mass, momentum & energy for natural convection past vertical plane surface, approximate integral boundary layer analysis for natural convection, working correlations for various shapes, natural convection from finned surface, natural convection in enclosed spaces, mixed free & forced convection.

UNIT–III: Forced convection inside tubes & ducts- Analysis of laminar forced convection in long tube, correlations for laminar forced correction, analogy between heat & momentum transfer in turbulent flow, working correlations for turbulent forced convection, forced convection in non-circular sections. Forced convection over exterior surfaces: Flow over bluff bodies, local heat transfer coefficient distribution around cylinders, effect of various parameters on local heat transfer coefficient, heat transfer from tube bundles in cross flow, heat transfer from non-circular sections.

UNIT–IV: Heat transfer- heat transfer in fixed bed, heat transfer in fluidized bed, heat transfer in cyclone heat exchanger. Heat transfer by combined conduction, convection & radiation: Thermocouple lead error in surface temperature measurements, heat transfer from radiating fins, flat plate solar collector, the heat pipe.

TEXT / REFERENCE BOOKS:

1. Kays, W M., & Crawford, M E., 'Convective Heat Transfer & Mass Transfer', 3rd Edition; McGraw Hill International Editions, 1993.
2. Kreith, F. & Bohn, M.S., 'Principles of Heat Transfer', 6th Edition; Asian Books Private Limited, 2001.
3. Ghosdastidar, P.S., 'Heat Transfer'; Oxford University Press, 2004.

NOTE: Five out of eight questions are to be attempted. Two questions are to be set from each unit.

CHE – 554 : PETROLEUM ENGINEERING (ELECTIVE-I)

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Scope and Purpose of Refining: Global and Indian refining scenario, Petroleum refining industry in India practice and prospects, An overview of the entire spectrum of the refinery products, refinery configuration development, Physical-chemical characteristics of Petroleum and Petroleum products.

UNIT-II: Refinery Distillation Processes: Desalting and Stabilization of crude, Process description of typical simple distillation, Fractional distillation, crude oil distillation, vacuum distillation etc. Degree of separation (5-95 gap) and degree of difficulty of separation (Δt 50), Packie charts, ASTM, TBP and EFV Distillation.

UNIT-III: Fuel Refining: Cracking, coking, reforming, alkylation, isomerisation polymerization, sweetening, visbreaking. Lube Refining- Solvent extraction, de-waxing propane de-asphalting. Wax Refining- De-oiling of crude wax, crystallization, catalytic, sweating microcrystalline and petroleum wax applications. Hydro processing-Hydro cracking, hydro treating, hydro finishing.

UNIT-IV: Refinery Feedstock: Nature and effect of different types of refinery feedstock and their impurities on refinery configuration and operation. Refinery Gas Processing-Process description of typical light ends unit, acid gas removal using gas treating processes.

UNIT-V: Two Phase Oil and Gas Separation equipment-Types, their description, vessel sizing. Theory of separation and separator design. Three Phase Oil Gas and Water Separators: Types of separators, their description. Various control and vessel internals, theory and sizing of three phase separator. LACT units.

TEXT / REFERENCE BOOKS:

1. Nelson W L, "Petroleum Refinery Engineering", Mc Graw Hill Book Co., 1985.
2. Watkins R N, "Petroleum Refinery Distillation", Gulf Publishing Co.
3. Gary J H and Handework G E, "Petroleum Refining Technology and Economics", Marcel Dekker, Inc., 2001.
4. Jones D S J, "Elements of Petroleum Processing", John Willey & Sons, 1995
5. Waquier J P, "Petroleum Refining" Vol. I & II Editions, Technip, 1995.

NOTE : Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 556 : FLUIDIZATION ENGINEERING (ELECTIVE-I)

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction-Fluidization phenomenon, behaviour of fluidized beds and industrial applications

UNIT-II: Packed Bed-Flow of fluids, Darcy's law and permeability, specific surface and voidage, general expressions for flow through beds, Carman –Kozeny equations, Molecular flow, Packing, Pressure drop

UNIT-III: Fluidized Beds- Properties of gas liquid and liquid-solid systems. Effect of fluid velocity on pressure gradient, minimum fluidizing, terminal velocity and pressure drop, types of fluidization, bubble formation , distributor, voidage, slugging and channeling, entrainment and elutriation

UNIT-IV: Application and Design Aspects-Heat and mass transfer in fluidized beds, introduction to design aspects of fluidized beds.

UNIT-V: Pneumatic and Hydraulic Conveying-Introduction, Pneumatic conveying of solids in vertical and horizontal conduits, hydraulic conveying of solids in vertical and horizontal conduits.

TEXT / REFERENCE BOOKS:

1. Fluidization Engineering by Kunii, D. And O. Levenspiel, Butterworth-Heinemann, 1991.
2. Chemical Engineering by Coulson, J.M. and Richardson, J.F., Vol. 2, 5th ed., Butterworth- Heinemann.
3. Fundamentals of Fluidized Bed Chemical Process by Yates, Y.G., Butterworth's.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 560 : CHEMICAL PROCESS INTEGRATION (ELECTIVE-II)

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction, Concepts of Pinch Analysis, Heat Integration, Synthesis of Heat Exchanger Networks, Minimum utility targeting, Heat Integrated Distillation Column, Heat Integration of Reactors

UNIT-II: Combined heat & Power Integration, Heat engines & Thermal Pinch Diagram, Heat Pumps & Thermal Pinch diagram, cogeneration targeting

UNIT-III: Mass integration strategies, Targeting for minimum discharge waste & minimum purchase of fresh material, Synthesis Mass Exchange Networks, Graphical & Algebriac approach to the targeting of Mass Exchange Networks, Mathematical techniques for the synthesis of Mass & Heat exchange network

TEXT / REFERENCE BOOKS:

1. Mahmoud M. El-Halwagi, 'Process Integration', Academic Press, 2006.
2. I.C. Kemp, 'Pinch Analysis and Process Integration', 2nd edition published by I.Chem. E and Elsevier, 2007.
3. Robin Smith , 'Chemical Process Design and Integration', John Wiley & Sons Ltd, 2005.
4. Douglas, 'J.M. Conceptual Design of Chemical Processes', McGraw-Hill, 1988.
5. Warren D. Seider, 'J.D. Seader, Daniel R. Lewin', Process Design Principles –Synthesis, Design, and Evaluation', John Wiley & Sons, 1999.
6. Richard Turton, Richard C. Bailie, Wallace B. Whiting, and Joseph A.Shaeiwitz,' Analysis, Synthesis, and Design of Chemical Processes', 2nd Edition, Prentice Hall International Series, 2003.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than three) is to be set from each unit.

CHE – 562 : RENEWABLE ENERGY TECHNOLOGIES (ELECTIVE-II)

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Principles of renewable energy: Fundamentals, scientific principles, technical implications and social implications.

UNIT-II: Solar radiation: Extraterrestrial solar radiation, measurement and estimation of solar radiation. Solar heating devices: Solar water heater: sheltered and unsheltered heaters, systems with separate storage, selective surfaces, solar ponds, solar concentrators and other devices.

UNIT-III: Principles of photovoltaic generation of electricity; silicon cell, photon absorption, cell efficiency, solar cell construction, types and usage of photovoltaic systems.

UNIT-IV: Biofuels: Biofuel classification, combustion, pyrolysis, gasification and other thermo-chemical processes, production of alcohol and biogas. Trans-esterification of vegetable oils for biodiesel production, characterization of biodiesel, economics, current trends, and future prospects in usage of biodiesel.

UNIT-V: Hydrogen Energy: Hydrogen energy system and analysis, hydrogen infrastructure, safety, codes and standards, hydrogen production: Electrolysis, thermo-chemical, Hydrogen from fossil fuel. Hydrogen storage: Carbon storage materials: Metal hydrides and chemical hydrides, cryogenic hydrogen storage, hydrogen fuel cells.

UNIT-VI: Biomass and other renewable sources of energy.

TEXT / REFERENCE BOOKS:

1. D S Chauhan, S K Srivastava, "Non Conventional energy resources", New Age International (P) limited.
2. D Mukherjee, S Chakrabarti, "Fundamentals of Renewable Energy", New Age International (P) limited.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 512 : PROCESS DYNAMICS AND CONTROL LAB

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
--	3	3	Class Work	:	50 Marks
			Examination	:	50 Marks
			Total	:	100 Marks
			Duration of Examination	:	3 Hours

List of Experiments:

1. Feed-backward control system
2. Feed-forward control system
3. Analysis of valve
4. Ratio Control system
5. Selective Control system
6. Cascade control system
7. Split range control system
8. Interacting and Non-interacting System
9. Multi-Process Trainer
10. PLC Trainer

CHE – 514 : SEMINAR-I

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits			
--	2	2	Class Work	:	50 Marks
			Total	:	50 Marks

The objectives of the course remain:

- To learn how to carry out literature search
- To learn the art of technical report writing
- To learn the art of verbal communication with the help of modern presentation techniques

A student will select a topic in emerging areas of Engineering & Technology and will carry out the task under the supervision of a teacher assigned by the department. He/She will give a seminar talk on the same before a committee constituted by the Chairperson of the department. The committee should comprise of 2 or 3 faculty members from different specializations. The teacher(s) associated in the committee will each be assigned 2 hours teaching load per week. However supervision of seminar topic will be in addition to regular teaching load.

CHE – 601 : OPTIMIZATION OF CHEMICAL PROCESSES

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction to optimization-Formulation of objective function, basic concepts- functions, regions, necessary and sufficient conditions for an extremum of an unconstrained function.

UNIT-II: One dimensional search -Scanning and bracketing; Newton, Quasi-Newton and secant method, Region elimination method; polynomial approximation methods.

UNIT-III: Unconstrained multi variable optimization-Direct methods-random search, grid search, uni-variate search, simplex method, conjugate search method and Powell's method, Indirect methods-gradient and conjugate gradient methods, Newton's method, movement in search direction, secant method.

UNIT-IV: Linear Programming-Formulation of LP problem, graphical solution of LP Problem, Simplex Method, Duality in Linear programming, two phase method

UNIT-V: Non-Linear Programming with constraints- Necessary and sufficiency conditions for a local extremum, quadratic programming, successive quadratic programming, Generalized reduced gradient (GRG) method Novel techniques for optimization – Simulated Annealing, Genetic Algorithm, Differential Evolution etc. Use of MS Excel and MAT LAB is advised for solving problems

TEXT / REFERENCE BOOKS:

1. Edgar, T.F., Himmelblau, D.M., Lasdon, L.S. , "Optimization of chemical process"' 2nd ed. Mc Graw-Hill, 2001
2. Rao, S.S.," Optimization Techniques"' Wiley Eastern, New Delhi, 1985.
3. Godfrey, C.O. and Babu, B.V.," New optimization techniques in engineering", Springer-Verlag, Germany, 2004
4. Beveridge, G. And Schechter, R.S., "Optimization Theory and Practice", McGraw Hill, New York, 1970.
5. Reklaitis, G.V., Ravindran, A and Ragsdell, K.M., "Engineering Optimization- Methods and Applications", John Wiley, New York, 1983.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 603 : ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Ecology and Environment, Sources of air, water and solid wastes, Air Pollution Micrometeorology, Control technologies: centrifugal collectors, electrostatic precipitator, bag filter and wet scrubbers, Design and efficiencies, Combustion generated pollution, vehicles emission control, Case studies.

UNIT-II: Water Pollution: Water quality modeling for streams. Characterisation of effluents, effluent standards, Treatment methods, Primary methods: settling, pH control, chemical treatment. Secondary method: Biological treatment, Tertiary treatments such as ozonisation, disinfection etc.

UNIT-III: Solid waste collection, treatment and disposal, Waste recovery system

TEXT / REFERENCE BOOKS:

1. Environmental and pollution Science by Ian L peeper, Charles P Garba and Mark L Bresseau; Publishers: Academic Press USA
2. Air pollution: H. C. Perkins; Mc Graw Hill
3. Waste Water System engineering: H W Parker; Prentice Hall of India
4. Waste Water Treatment, Disposal and Refuse: Metcalf and Eddy Tata-McGraw Hill.
5. A.P.F. Turner, I. Karube, & G.S.Wilsons Biosensors: Fundamentals and Applications, Oxford Science Publications: Oxford, 1987.
6. Ashok Mulchandani and Kim R. Rogers, Enzyme and Microbial Biosensors: Techniques and Protocols, (Eds); Humana Press, Totowa, NJ, 1998.
7. Solid Wastes, Martell, 1975, John Wiley, NY.
8. Solid Wastes, George Tchobanuglour, H.Theisen and R.Eliassen.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than three) is to be set from each unit.

CHE – 605 : DISSERTATION (PHASE-I)

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
--	4	4	Class Work	:	100 Marks
			Total	:	100 Marks

The primary objective of this course is to develop in student the capacity for analysis & judgment and the ability to carry out independent investigation in design/development through a dissertation work involving creativity, innovation and ingenuity. The work must start with comprehensive literature search and critical appreciation thereof so as to select research problem the student wishes to work on.

Each student will carry out independent dissertation under the supervision of some teacher(s) who will be called Supervisor(s). In no case more than two supervisors can be associated with one dissertation work.

The dissertation involving design/fabrication testing/computer simulation/case studies etc. which commences in the III semester will be completed in IV Semester. The evaluation of the dissertation phase-I besides approval of the dissertation topic of the students will be done by a committee of three members constituted as under:

Chairperson of Department	:	Chairperson
M.Tech. Coordinator/Senior faculty	:	Member Secretary
Respective dissertation supervisor	:	Member

The student will be required to submit two copies of his/her report to the department for record (one copy each for the department and participating teacher).

CHE – 651 : POLYMERS SCIENCE AND ENGINEERING (ELECTIVE-III)

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Introduction to polymer science-Classification of polymers, polymer structure, polymer structure, molecular weight, chemical structure and thermal transitions. The synthesis of high polymers: Step growth polymerization, chain growth polymerization, polymerization techniques, reactions of synthetic polymers, special topics in polymer synthesis, chemical structure determination.

UNIT-II: Solution properties, thermodynamics, and molecular weight determination. The solid state properties of polymers: Amorphous state, crystalline state, thermal transition properties, mechanical properties. Visco-elasticity and rubber elasticity. Degradation, stability, and environmental issues: polymer degradation and stability, management of plastics in the environment.

UNIT-III: Polymer additives, blends, and composites. Commodity thermoplastics and fibers. Network polymers: Elastomers and thermosets. Engineering and specialty polymers: polyamides, ABS, polycarbonates, modified poly(phenylene oxide), acetal, polysulfones, poly(phenylene sulphide), engineering polyesters, fluoropolymers, polyimides, ionic polymers polyaryetherketones, specialty polyolefins, inorganic polymers, liquid-crystal polymers, conductive polymers, high performance fibres, others.

UNIT-IV: Polymer processing and rheology: Extrusion and extruders, calendering, roller and blade coating, film blowing. Fibre spinning injection moulding. Compression and transfer moulding, compounding and mixing. Twin screw extruder, Banburry and other mixing equipments in polymer processing, introduction to polymer rheology, analysis of simple flows, rheometry, modeling of polymer- processing operations.

UNIT-V: Applications for polymers: membrane separations, Biomedical separations, applications in electronics, photonic polymers, drag reduction.

TEXT / REFERENCE BOOKS:

1. Joel R. Fried, "Polymer science and technology", Prentice Hall of India.
2. Sinha,R. "Outlines of polymer technology: Manufacture of polymers", Prentice Hall of India.
3. Middleman, S., "Fundamentals of polymer processing", McGraw Hill Book company.
4. Morrison F.A., "Understanding Rheology", Oxford University press.
5. Tadmor, Z. and Gojos C.G., "Principles of polymer processing", Wiley-interscience New york.
6. Dr. Shrikant D. Dawande, "Introduction to polymer Science and technology", Denett.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 653 : FUEL CELL TECHNOLOGIES (ELECTIVE-III)

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Fuel cell- Introduction; types of fuel cells; advantages and disadvantages.Thermodynamics- Work potential; electrode potential; reversible voltage; thermodynamic efficiency Electrochemical reaction kinetics- Reaction rate; Exchange current density; Galvani potential; Butler-Volmer equation; Tafel equation.

UNIT-II: Charge transport-Forces for charge transport; voltage loss due to charge transport; transport resistances; electrolytes.

UNIT-III: Mass transport- Diffusive transport; convective transport; flow structure design. Modeling- Flux balance; governing equations.

UNIT-IV: Fuel cell characterization: In-situ technique: current-voltage measurement, electrochemical impedance spectroscopy, cyclic voltametry; Ex-situ technique: porosity determination, BET surface are determination, gas permeability, structure and chemical determination.

TEXT / REFERENCE BOOKS:

1. Fuel Cell Fundamentals by R P O'Hayre, S Cha, W Colella, F B Prinz; John Wiley & Sons, Inc.
2. Fuel Cell Systems Explained by J Larminie, A Dicks; Wiley.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two) is to be set from each unit.

CHE – 655 : INDUSTRIAL RISK AND SAFETY MANAGEMENT (ELECTIVE-III)

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
4	--	4	Class Work	:	50 Marks
			Examination	:	100 Marks
			Total	:	150 Marks
			Duration of Examination	:	3 Hours

UNIT-I: Hazard identification methodologies, risk assessment methods-PHA, HAZOP, MCA, ETA, FT A, Consequence analysis, Probit Analysis.

UNIT-II: Hazards in work places- Nature and type of Work places, Types of hazards, hazards due to improper housekeeping, hazards due to fire in multi floor industries and buildings, guidelines and safe methods in above situations. Workers' exposures to hazardous chemicals, TLV s of Chemicals, Physical and Chemical properties of chemicals leading to accidents like fire explosion ingestion and inhalation, pollution in work place due to hazardous, dust, fumes and vapors, guidelines and safety methods in chemical handling, storage entry to confined space.

UNIT-III: Hazards in industries like fertilizer, heavy chemicals, petroleum, pulp and paper, tanneries, dies, paints, pesticides, glass and ceramics, dairy and sugar industries, guidelines for safeguarding personnel and safeguarding against water, land and air pollution in the above industries.

UNIT-IV: Safety education and training-Safety managements, fundamentals of safety tenets, measuring safety performance, motivating safety performance, legal aspects of industrial safety, safety audits.

TEXT / REFERENCE BOOKS:

1. Loss prevention in process industries, 2/e, F.P. Less 1986 Butterworth Heinemann.
2. Techniques of safety managements, D.Patterson, 1978, Mc-Graw-Hill.
3. Industrial Safety hand book, 2/e, W. Handley, 1977, McGraw-Hill.
4. Protecting personnel at hazardous waste sites, S.P. Levine, 1985, Martin, Butterworth.
5. Industrial Safety, R.P. Blake, 1953, Prentice Hall.
6. Chemical Process Safety, Crawl D A, and Louvar J F, Prentice Hall, New Jersey.

NOTE: Five out of eight questions are to be attempted. At least one question (not more than two is to be set from each unit.

CHE – 609 : ENVIRONMENTAL ENGINEERING LAB

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
--	3	3	Class Work	:	50 Marks
			Examination	:	50 Marks
			Total	:	100 Marks
			Duration of Examination	:	3 Hours

List of Experiments:

1. Determination of Dissolved oxygen
2. Determination of BOD
3. Determination of COD
4. Determination of Acidity
5. Determination of Alkalinity
6. Determination of Total Hardness
7. Determination of Dissolved Solids
8. Determination of Volatile matter
9. Determination of Sulphates
10. Determination of Chlorides
11. Determination of Heavy metals (Atomic Absorption Spectrophotometer with Hydride generator, HPLC)
12. Stack Gas Analysis – NOX, SOX, COX, SPM

CHE – 611 : SEMINAR-II

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits			
--	2	2	Class Work	:	50 Marks
			Total	:	50 Marks

The objectives of the course remain:

- To learn how to carry out literature search
- To learn the art of technical report writing
- To learn the art of verbal communication with the help of modern presentation techniques

A student will select a topic in emerging areas of Engineering & Technology and will carry out the task under the supervision of a teacher assigned by the department. He/She will give a seminar talk on the same before a committee constituted by the Chairperson of the department. The committee should comprise of 2 or 3 faculty members from different specializations. The teacher(s) associated in the committee will each be assigned 2 hours teaching load per week. However supervision of seminar topic will be in addition to regular teaching load.

CHE – 602 : DISSERTATION

M. Tech. Semester - IV (Chemical Engineering)

L	P	Credits			
--	25	25	Class Work	:	250 Marks
			Examination	:	500 Marks
			Total	:	750 Marks
			Duration of Examination	:	3 Hours

The Dissertation started in IIIrd Semester will be completed in IV Semester and will be evaluated in the following manner.

Internal Assessment

Internal Assessment (Class work evaluation) will be effected as per ordinance through interim report, presentation and discussion thereon by the following committee of three members.

Chairperson of Department	:	Chairperson
M.Tech. Coordinator/Sr. Faculty	:	Member Secretary
Respective dissertation Supervisor	:	Member

External Assessment

Final dissertation will be assessed by a panel of examiners consisting of the following

Chairperson of Department	:	Chairperson
Respective Supervisor(s)	:	Member(s)
External expert	:	To be appointed by the University

Note: 1. M.Tech. Coordinator shall coordinate the work of dissertation exam.

2. The External Expert must be from the respective area of specialization. The Chairperson & M. Tech Co-ordinator with mutual consultation will divide the submitted dissertations into groups depending upon the area of specialization and will recommend the list of experts for each group separately to the V C for selecting the examiners with the note that an external expert should be assigned a maximum of FIVE dissertations for evaluation.

The student will be required to submit THREE copies of his/her report to the M.Tech. Co-ordinator for record and processing.