

**SCHEME
OF
STUDIES AND EXAMINATIONS**

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. 2012-13

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	CHE501B	MODELING AND SIMULATION	4	-	4	25	75	-	100	4	3
2	CHE503B	ADVANCED TRANSPORT PHENOMENA	4	-	4	25	75	-	100	4	3
3	CHE505B	ADVANCED THERMODYNAMICS	4	-	4	25	75	-	100	4	3
4	CHE507B	APPLIED MATHEMATICS IN CHEMICAL ENGINEERING	4	-	4	25	75	-	100	4	3
5	CHE509B	ADVANCED CHEMICAL REACTION ENGG.	4	-	4	25	75	-	100	4	3
6	CHE511B	MODELING AND SIMULATION LAB	-	3	3	40	-	60	100	1.5	3
TOTAL			20	3	23	165	375	60	600	21.5	

NOTE:

1. The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.
2. Electronics gadgets including Cellular phones are not allowed in the examination.

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. 2012-13

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	CHE502B	ADVANCED PROCESS DYNAMICS AND CONTROL	4	-	4	25	75	-	100	4	3
2	CHE504B	ADVANCED SEPARATION PROCESSES	4	-	4	25	75	-	100	4	3
3	CHE506B	ADVANCED HEAT TRANSFER	4	-	4	25	75	-	100	4	3
4	CHE-	ELECTIVE-I	4	-	4	25	75	-	100	4	3
5	CHE-	ELECTIVE-II	4	-	4	25	75	-	100	4	3
6	CHE512B	PROCESS DYNAMICS AND CONTROL LAB	-	3	3	40	-	60	100	1.5	3
7	CHE514B	SEMINAR - I	-	2	2	50	-	-	50	2	-
TOTAL			20	5	25	215	375	60	650	23.5	

Elective-I:

1. CHE554B: PETROLEUM ENGINEERING
2. CHE556B: FLUIDIZATION ENGINEERING.

Elective-II:

1. CHE560B: CHEMICAL PROCESS INTEGRATION
2. CHE562B: RENEWABLE ENERGY TECHNOLOGIES.

Note:

1. The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.
2. Electronics gadgets including Cellular phones are not allowed in the examination.
3. The choice of the students for any elective shall not be a binding for the department to offer, if the department does not have expertise. The minimum strength of the students should be 08 to run an elective course.

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. 2013-14

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	CHE601B	OPTIMIZATION OF CHEMICAL PROCESSES	4	-	4	25	75	-	100	4	3
2	CHE603B	ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT	4	-	4	25	75	-	100	4	3
3	CHE605B	DISSERTATION(PHASE-I)	-	4	4	100	-	-	100	4	-
4	CHE-	ELECTIVE III	4	-	4	25	75	-	100	4	3
5	CHE609B	ENVIRONMENTAL ENGG. LAB	-	3	3	40	-	60	100	1.5	3
6	CHE611B	SEMINAR - II	-	2	2	50	-	-	50	2	-
TOTAL			12	9	21	265	225	60	550	19.5	

Elective-III:

1. CHE651B: POLYMER SCIENCE AND ENGINEERING
2. CHE653B: FUEL CELL TECHNOLOGIES.
3. CHE655B: INDUSTRIAL RISK AND SAFETY MANAGEMENT.

Note:

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3. The choice of the students for any elective shall not be a binding for the department to offer, if the department does not have expertise. The minimum strength of the students should be 08 to run an elective course.

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. 2013-14

S. No.	Course No.	Course Title	Teaching Schedule			Marks of Class work	Examination Marks		Total	Credit	Duration of Exam
			L	P			Theory	Practical			
1	CHE602B	DISSERTATION	-	20		50	-	100	150	20	3
TOTAL			-	20		50	-	100	150	20	

SYLLABUS

CHE501B : MODELING AND SIMULATION
M. Tech. Semester - I (Chemical Engineering)

L P Credits
4 -- 4

Class Work : 25Marks
Examination : 75 Marks
Total : 100 Marks
Duration of Examination : 3 Hours

- UNIT-I:** Introduction: Types of Models and Model building. Mathematical models, Use of Mathematical Models, Scope of coverage, Lumped and distributed parameter models both steady and unsteady state. Principles of formulation, Fundamental laws, continuity equations, energy equations, equations of motion, transport equations, equation of state, equilibrium, chemical kinetics.
- UNIT-II:** Series of isothermal constant hold up CSTRs, Gravity flow tank, CSTRs with variable hold ups, Heated tanks, Gas phase pressurized CSTR, Isothermal and non-isothermal CSTRs systems. Single and Multi-component vaporizers. Numerical and software simulation techniques. Interval Halving, False position Newton Raphson Methods etc., Numerical integration, Euler's method
- UNIT-III:** 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, absorption column, multi stage counter current extraction and liquid liquid extraction
- UNIT-IV:** Semi batch reactor, Mixing Process, Adsorption systems, heat exchangers and evaporators, cooling towers, fluid catalytic cracking, Trickle bed reactor, Bioreactor, Interacting and Non -interacting tanks, stirred tank heaters

TEXT / REFERENCE BOOKS:

1. W.L.Luyben, Process Modeling, Simulation and Control for Chemical Engineers, Mcgraw-Hill (1990)
2. W.F.Ramirez, Computational Methods In Process Simulation, Butterworth, 1989.
3. R.E.Franks, Modeling and Simulation in Chemical Engineering, John Wiley, 1972
4. Chemical Process simulation: Asghar Husain- Wiley Eastern.
5. Chemical Engineering Dynamics: E.J. Dunn- V.C.H.

NOTE:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE505B : ADVANCED THERMODYNAMICS
M. Tech. Semester - I (Chemical Engineering)

L P Credits
4 -- 4

Class Work : 25 Marks
Examination : 75 Marks
Total : 100 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. 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-II: Thermodynamic Properties of Fluids: Fundamental property relations, Maxwell's equations, Residual properties, Clapeyron's Equation, Generalized correlations for thermodynamic properties of gases. 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-III: 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. Solution Thermodynamics: Ideal solution, Fundamental residual-property relation, Fundamental excess-property relation, Evaluation of partial properties. Heat effects of mixing processes. Partially miscible systems.

UNIT-IV: 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. 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE507B : APPLIED MATHEMATICS IN CHEMICAL ENGINEERING
M. Tech. Semester - I (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 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. Numerical solutions of ordinary differential: Initial value problems: single step methods, multi-step methods; boundary value problems - solution procedure by finite difference scheme.

UNIT-IV: 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
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CHE 509B : ADVANCED CHEMICAL REACTION ENGINEERING
M. Tech. Semester - I (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 Marks
			Duration of Examination	: 3 Hours

- UNIT-I:** Kinetics of Heterogeneous Reactions - Rate controlling steps, Langmuir-Hinshelwood kinetics. External Diffusion Effects in Heterogeneous Reactions; Mass Transfer limited reactions in packed beds, Modeling diffusion with and without reaction; Non catalytic fluid-solid reaction- Shrinking and Unreacted Core Model.
- UNIT-II:** Internal Transport Processes in Porous Catalysts -Intra pellet mass transfer, Evaluation of effectiveness factor, Mass transfer with reaction in packed bed.
- UNIT-III:** Design of Heterogeneous Catalytic Reactors-Isothermal and adiabatic fixed bed reactors, Non-isothermal and non adiabatic fixed bed reactors. Slurry reactor model, Trickle bed reactor model.
- UNIT-IV:** Non-Ideal Flow-Residence Time Distribution, Dispersion Model, Tanks-in-Series Model, Mixing concepts, Segregated Flow 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
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CHE511B : MODELING AND SIMULATION LAB
M. Tech. Semester - I (Chemical Engineering)

L P Credits
-- 3 1.5

Class Work : 40 Marks
Examination : 60 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.

NOTE:

1. **The students will be required to perform the 08 experiments/exercises from the above list and any other two experiments designed by the department based on the theory course(CHE501B : Modeling And Simulation).**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE502B : ADVANCED PROCESS DYNAMICS AND CONTROL
M. Tech. Semester - II (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 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, Bode diagrams, Bode stability criterion, Zigler-Nichols and Cohen-Coon tuning methods, Process Identification
- UNIT-III:** Advanced Control Systems-Feedback- control of systems with Large Dead Time, Feed-forward and Ratio Control, Adaptive and Inferential Control Systems.
- UNIT-IV:** Multi-loop and Multivariable Control-Control Loop Interactions, Bristol’s Relative Gain Array Method, Singular Value Analysis. Sampled data control systems: Sampling Continuous Signals, Basic review of z-Transforms, Discrete-Time response of dynamic system, Design of digital 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
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CHE504B : ADVANCED SEPARATION PROCESSES
M. Tech. Semester - II (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 Marks
			Duration of Examination	: 3 Hours

UNIT-I: Membrane separation-Characterization of membranes; transport through porous and non-porous membranes;

UNIT-II: Reverse osmosis, electro dialysis, gas permeation; pervaporation, concentration, pressure, electrically and thermally driven membrane processes; membrane reactors; polarization; fouling; modules; energy requirements.

UNIT- III: 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- IV: 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 Processes 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 Krukoni; Butterworth.

NOTE:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
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CHE554B : PETROLEUM ENGINEERING (ELECTIVE-I)

M. Tech. Semester - II (Chemical Engineering)

L P Credits
4 -- 4

Class Work : 25 Marks
Examination : 75 Marks
Total : 100 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. Refinery Feedstock: Nature and effect of different types of refinery feedstock and their impurities on refinery configuration and operation.

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. Refinery Gas Processing-Process description of typical light ends unit, acid gas removal using gas treating processes.

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: 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", McGraw Hill Book Co., 1985.
2. Watkins R N, "Petroleum Refinery Distillation", Gulf Publishing Co.
3. Gary JH 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:

1. In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.
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CHE556B : FLUIDIZATION ENGINEERING (ELECTIVE-I)
M. Tech. Semester - II (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 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. Application and Design Aspects-Heat and mass transfer in fluidized beds, introduction to design aspects of fluidized beds.

UNIT-IV: 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:

1. In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.
2. The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.
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CHE560B : CHEMICAL PROCESS INTEGRATION (ELECTIVE-II)
M. Tech. Semester - II (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 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,
- UNIT-IV:** Synthesis Mass Exchange Networks, Graphical & Algebraic 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE562B : RENEWABLE ENERGY TECHNOLOGIES (ELECTIVE-II)

M. Tech. Semester - II (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 Marks
			Duration of Examination	: 3 Hours

UNIT-I: Principles of renewable energy, Energy utilization, Fundamentals, scientific principles, technical implications and social implications. Renewable Energy resources and their potential, New Energy Sources, Energy Conversion technologies. Wind Energy, Wind mill and turbine, Wind Power plant, classification and principles of power generation, wind mill/ turbine design, operation and control, site selection, Wind energy applications and new developments.

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

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

UNIT-IV: New Energy Sources: Geothermal energy, tidal energy, Wave energy, Ocean thermal energy, Peat, Oil shale, small hydel power, agriculture residues, Draught animals, Hydrogen Energy: Hydrogen energy system and analysis, hydrogen production: Electrolysis, thermo-chemical, Hydrogen from fossil fuel. Hydrogen storage: Carbon storage materials: cryogenic hydrogen storage, hydrogen fuel cells.

TEXT / REFERENCE BOOKS:

1. Dr R K Singhal, "Non-conventional energy sources", S K Kataria & Sons, Darya Ganj, New Delhi
2. D S Chauhan, S K Srivastava, "Non Conventional energy resources", New Age International (P) limited.
3. D Mukherjee, S Chakrabarti, "Fundamentals of Renewable Energy", New Age International (P) limited.

NOTE:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE514B : SEMINAR-I
M. Tech. Semester - II (Chemical Engineering)

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

CHE601B : OPTIMIZATION OF CHEMICAL PROCESSES
M. Tech. Semester - III (Chemical Engineering)

L P Credits
4 -- 4

Class Work : 25 Marks
Examination : 75 Marks
Total : 100 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. One dimensional search -Scanning and bracketing; Newton, Quasi-Newton and secant method, Region elimination method; polynomial approximation methods.

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

UNIT-IV: 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. McGraw-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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE603B : ENVIRONMENTAL ENGINEERING AND WASTE MANAGEMENT
M. Tech. Semester - III (Chemical Engineering)

L	T	P	Credits	Class Work	: 25 Marks
4	-	-	4	Examination	: 75 Marks
				Total	: 100 Marks
				Duration of Examination	: 3 Hours

UNIT-I: Inter relationship between energy and pollution, Global warming, ozone layer depletion, effect of change in climate on ecosystem and world economy.

UNIT-II: Sources & effects of air pollution on human beings & plant life, Air Sampling, Meteorological aspects of air pollution problems, inversion, plumes and behavior of plumes and different atmospheric stability conditions. Air pollution Control technologies: settling chambers, cyclones, electrostatic precipitator, bag filter and wet scrubbers, Design and efficiencies, Combustion generated pollution, vehicles emission control, air pollution legislation and regulations.

UNIT-III: Water Pollution: types of water pollutants, sources and effects of water pollutants, waste water characteristics (BOD, DO, COD etc.) effluent standards. Treatment methods, Primary methods: screening, sedimentation, filtration etc. Secondary method: Biological treatments Activated sludge process, Trickling filters, Tertiary treatments such as ozonisation, adsorption, disinfection etc. Sludge treatment and disposal methods, water pollution legislation and regulations.

UNIT-IV: Solid waste collection, treatment and disposal, Waste recovery system, e-waste. Introduction to Environmental impact assessment (EIA),

TEXT BOOKS

1. "Environmental Engineering", Peavy H.S. and Rowe D.R.-McGraw Hill.
2. "Environment Pollution Control Engineering", revised second edition, C.S.Rao, New Age International Limited Publishers.

REFERENCE BOOKS

1. "Air Pollution", M.N. Rao and H.V.N. Rao- Tata McGraw Hill.
2. "Environmental Engineering", G.N. Panday and G.C. Carney- Tata McGraw Hill.
3. "Wastewater treatment disposal and Reuse", Metcalf and Eddy - Tata McGraw Hill.
4. "Waste Water System engineering" H W Parker; Prentice Hall of India

NOTE:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination**

CHE605B : DISSERTATION (PHASE-I)
M. Tech. Semester - III (Chemical Engineering)

L	P	Credits	Class Work	: 100 Marks
--	4	4	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).

The project coordinator will be assigned the project load of maximum of 2 hours per week including his own guiding load of one hour. However, the guiding teacher will be assigned maximum of one period of teaching load irrespective of number of students/groups under him/her.

CHE651B : POLYMERS SCIENCE AND ENGINEERING (ELECTIVE-III)

M. Tech. Semester - III (Chemical Engineering)

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 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. Viscoelasticity 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, calendaring, 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.
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:

1. In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.
2. The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.
3. Electronics gadgets including Cellular phones are not allowed in the examination

CHE653B : FUEL CELL TECHNOLOGIES (ELECTIVE-III)**M. Tech. Semester - III (Chemical Engineering)**

L **P** **Credits**
4 **--** **4**

Class Work : **25 Marks**
Examination : **75 Marks**
Total : **100 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 area 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE655B : INDUSTRIAL RISK AND SAFETY MANAGEMENT (ELECTIVE-III)**M. Tech. Semester - III (Chemical Engineering)**

L	P	Credits	Class Work	: 25 Marks
4	--	4	Examination	: 75 Marks
			Total	: 100 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:

1. **In the semester examination, the examiner will set 08 questions in all selecting two from each unit. The candidates will be required to attempt five questions in all selecting at least one from each unit. All questions will carry equal marks.**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination.**

CHE609B : ENVIRONMENTAL ENGINEERING LAB
M. Tech. Semester - III (Chemical Engineering)

L	T	P	Credits	Class Work	: 40 Marks
-	-	3	1.5	Examination	: 60 Marks
				Total	: 100 Marks
				Duration of Examination	: 3 Hours

List of Experiments / Exercises:

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 (using Spectrophotometer)
12. Stack Gas Analysis – NOX, SOX, COX, SPM

NOTE:

1. **The students will be required to perform the 08 experiments/exercises from the above list and any other two experiments designed by the department based on the theory course (CHE603B : Environmental Engineering And Waste Management).**
2. **The students will be allowed to use non-programmable scientific calculator. However, sharing/exchange of calculator is prohibited in the examination.**
3. **Electronics gadgets including Cellular phones are not allowed in the examination**

CHE611B : SEMINAR-II
M. Tech. Semester - III (Chemical Engineering)

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

CHE602B : DISSERTATION
M. Tech. Semester - IV (Chemical Engineering)

L	P	Credits	Class Work	: 50 Marks
--	20	20	Examination	: 100 Marks
			Total	: 150 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.
3. The student will be required to submit THREE copies of his/ her report to the M.Tech. Co-ordinator for record and processing.
4. The project coordinator will be assigned the project load of maximum of 2 hours per week including his own guiding load of one hour. However, the guiding teacher will be assigned maximum of one period of teaching load irrespective of number of students/groups under him/her.