M. TECH. DEGREE PROGRAMME
IN CHEMICAL ENGINEERING

CURRICULUM AND SYLLABI

DEPARTMENT OF CHEMICAL ENGINEERING

HARCOURT BUTLER TECHNICAL UNIVERSITY

KANPUR

Chemical Engineering Department

OUR VISION

To emerge as a global leader in the areas of education and research in Chemical Engineering to handle the technological challanges in Chemical Engineering & Allied Field and catering the requirement of present and future stakeholders and society.

OUR MISSION

1. To provide state-of-art technical education to the undergraduate and post graduate students.
2. To create a conducive and supportive environment for the overall growth of our students.
3. To cultivate awareness of social responsibilities in students to serve the society.
4. To groom students with leadership skills helpful in Startups, professional ethics and accountability along with technical knowledge to face the changing needs of industry and environment.
5. To impart consultancy services to the Chemical and Allied industries of the local region and state.

Programme Educational Outcomes (PEOs)

Post Graduates from our department will be able to

1. Independently conduct fundamental and applied research in industries and academia.
2. Work in a team for a multidisciplinary approach in problem solving for varied fields like biotechnology, refinery and processing industries.
3. Demonstrate good professional ethics and engineering judgment on the global, economical, environmental and social issues.

Programme Specific Outcomes (PSOs)

1. Identify, formulate and solve engineering problems in core chemical industries such as refineries and fertilizer manufacturing units.
2. Undertake technical projects and consultancy in their chosen fields of specialization.
3. Contribute to the development of scientific and technical knowledge by effectively communicating the acquired knowledge and core competence among students, industry professionals, clients and society.

M. TECH. (CHEMICAL ENGINEERING)
Harcourt Butler Technical University, Kanpur
Course Structure and Evaluation Scheme
[Effective from the Session 2017-18]

M. Tech. (Chem. Engg)
Year I, Semester – I

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	TCH501	Advanced Mathematical Methods in Chemical Engg.	4 [4-0-0]	30	20	-	50	50	100
2	PCC	TCH503	Advanced Chemical Engineering Thermodynamics	4 [4-0-0]	30	20	-	50	50	100
3	PCC	TCH505	Advanced Chemical Reaction Engineering	4 [4-0-0]	30	20	-	50	50	100
4	PCE	TCH521-527	Elective - I	4 [4-0-0]	30	20	-	50	50	100
			Total Credits	**16**						

Elective - I [4-0-0]

TCH521 Air Pollution Monitoring and Control
TCH523 Safety Hazard and Risk Analysis
TCH525 Instrumental Methods of Analysis
TCH527 Advanced Petroleum Refining

M. Tech. (Chem. Engg.)
Year I, Semester - II

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	TCH502	Advanced Transport Phenomena	4 [4-0-0]	30	20	-	50	50	100
2	PCC	TCH504	Advanced Separation Processes	4 [4-0-0]	30	20	-	50	50	100
3	PCC	TCH506	Optimization of Chemical Processes	4 [4-0-0]	30	20	-	50	50	100
4	PCE	TCH522-528	Elective - II	4 [4-0-0]	30	20	-	50	50	100
			Total Credits	**16**						

Elective - II [4-0-0]

TCH522 Advanced Process Control
TCH524 Statistical Design of Experiments
TCH526 Design of Piping System for Chemical Plants
TCH528 Water Pollution Monitoring and Control

M. Tech. (Chem. Engg.)
Year II, Semester - III

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	TCH601	Modeling and Simulation of Chemical Processes	4 [4-0-0]	30	20	-	50	50	100
2	PCC	TCH 603	Design & Simulation Lab	2 [0-0-6]	-	20	30	50	50	100
3	PCE	TCH631-637	Elective-III	4 [4-0-0]	30	20	-	50	50	100
4	PCC	TCH695	Seminar	2 [0-0-4]		50	-	50	50	100
5	PCC	TCH697	Dissertation	4 [0-0-8]		50	-	50	50	100
			Total Credits	**16**						

*** for Seminar & Dissertation TA 50 marks by supervisor and Rest 50 marks by DPGC**

Elective – III [4-0-0]

TCH631 Principles of Polymer Engineering
TCH633 Solar Thermal Energy Storage
TCH635 Nano Technology
TCH637 Natural Gas Engineering

M. Tech. (Chem. Engg.)
Year II, Semester –IV

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	TCH698	Dissertation	12 [0-0-24]	-	50	-	50	50	100
			Total Credits	**12**						

*** for Dissertation TA 50 marks by Supervisor and Rest 50 marks by External Examiner**

M. TECH. (CHEMICAL ENGINEERING) PART TIME
Harcourt Butler Technological Institute, Kanpur
Course Structure and Evaluation Scheme

[Effective from the Session 2017-18]

M. Tech. (Chem. Engg) PT Year 1, Semester - I

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks					Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total			
1	PCC	TCH501	Advanced Mathematical Methods in Chemical Engg.	4 [4-0-0]	30	20	-	50	50	100	1
2	PCC	TCH503	Advanced Chemical Engineering Thermodynamics	4 [4-0-0]	30	20	-	50	50	100	2
3	PCC	TCH505	Advanced Chemical Reaction Engineering	4 [4-0-0]	30	20	-	50	50	100	3
			Total Credits	**12**							

M. Tech. (Chem. Engg.)PT
Year 1, Semester - II

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks					Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total			
1	PCC	TCH502	Advanced Transport Phenomena	4 [4-0-0]	30	20	-	50	50	100	1
2	PCC	TCH504	Advanced Separation Processes	4 [4-0-0]	30	20	-	50	50	100	2
3	PCC	TCH506	Optimization of Chemical Processes	4 [4-0-0]	30	20	-	50	50	100	3
			Total Credits	**12**							

M. Tech. (Chem. Engg)PT
Year II, Semester - III

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					CT	TA	Lab.	Total		
1	PCC	TCH601	Modeling and Simulation of Chemical Processes	4 [4-0-0]	30	20	-	50	50	100
2	PCE	TCH621-627	Elective – I	4 [4-0-0]	30	20	-	50	50	100
			Total Credits	**08**						

Elective - I [4-0-0]

TCH621 Air Pollution Monitoring and Control
TCH623 Safety Hazard and Risk Analysis
TCH625 Instrumental Methods of Analysis
TCH627 Advanced Petroleum Refining

M. Tech. (Chem. Engg.)PT
Year II, Semester - IV

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					MSE	TA	Lab.	Total		
1	PCE	TCH622-628	Elective-II	4 [4-0-0]	30	20	-	50	50	100
2	PCC	TCH 695	Seminar	2 [0-0-4]	-	50	-	50	50	100
3	PCC	TCH697	Minor Project	2 [0-0-4]	-	50	-	50	50	100
			Total Credits	**08**						

*** for Seminar & Dissertation TA 50 marks by supervisor and Rest 50 marks by DPGC**

Elective - II [4-0-0]

TCH622 Advanced Process Control
TCH624 Statistical Design of Experiments
TCH626 Design of Piping System for Chemical Plants
TCH628 Water Pollution Monitoring and Control

M. Tech. (Chem. Engg.) PT
Year III, Semester - V

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					MSE	TA	Lab.	Total		
1	PCE	TCH731-737	Elective-III	4 [4-0-0]	30	20	-	50	50	100
2	PCC	QCH 797	Dissertation	4 [0-0-8]	-	50	-	50	50	100
			Total Credits	**06**						

*** for Seminar & Dissertation TA 50 marks by supervisor and Rest 50 marks by DPGC**

Elective – III
TCH731 Principles of Polymer Engineering
TCH733 Solar Thermal Energy Storage
TCH735 Nano Technology
TCH737 Natural Gas Engineering

M. Tech. (Chem. Engg.) PT
Year III, Semester –VI

Sl. No.	Course Type	Course Code	Subject	Credit	Sessional Marks				Sem. Final Exam.	Subject Total
					MSE	TA	Lab.	Total		
1	PCC	TCH 798	Dissertation	12 [0-0-24]	-	50	-	50	50	100
			Total Credits	**12**						

*** for Seminar & Dissertation TA 50 marks by supervisor and Rest 50 marks by External Examiner**

SYLLABUS
M. TECH CHEMICAL ENGINEERING

TCH 501 ADVANCED MATHEMATICAL METHODS IN CHEMICAL ENGINEERING

L	T	P	C
4	0	0	4

Assessment:

Sessional: 50 marks

End Semester: 50 marks

Course Objectives: To give students an insight in various Chemical Engineering processes using advanced analytical methods and also provide adequate background of Mathematics to deal with Chemical Engineering Problems, to understand research papers on relevant topics involving advanced Mathematics.

Course Outcomes:

Students completing the course will be able to

CO 1. Solve problems of algebraic equations.

CO 2. Solve problems of differential equations and simultaneous equation.

CO 3. Solve problems of partial differential equations.

CO 4. Apply Frobinious method to solve Bessel equation.

CO 5. Apply Frobinious method to solve hypergeometric equation.

Module 1 (12 Lectures)

Ordinary Differential Equations, Separable equations, Equations made separable by change of variables, Homogeneous Equations, Equations with first order and first degree with linear coefficients, Exact equations, Linear equation of first order, Bernoulli's equation, Other integrating factors, Integration of Exact equations, Equations of first order and higher degree, Clairaut's equation, Singular solutions, Equations with missing terms, General properties of Linear equations, Linear equations with constant coefficients, Determination of the complementary function, exponential functions, Determination of the particular integral, the Euler equation, Simultaneous Linear Differential equations.

Module 2 (6 Lectures)

Power series method, theory of the power series method, Legendre's equation, Legendre's Polynomials, Frobenius Method.

Module 3 (6 Lectures)

Bessel's equation, Bessel Functions $J_v(x)$, Bessel Functions $J_v(x)$ for any $v \geq 0$. Gamma Function, Solution $J_{-v}(x)$ of the Bessel Equation, Backbones of Bessel's Theory, $J_v(x)$ with $v = \pm 1/2, \pm 3/2, \pm 5/2$.

Module 4 (8 Lectures)

Definition of matrix, some special definitions and operations involving matrices, Determinants, Theorems on determinants, Inverse of a matrix, Orthogonal and unitary matrix. Orthogonal vectors, System of linear equations, Systems on n equations with n unknowns, Cramer's Rule, Eigen values and Eigen vectors.

Module 5 (8 Lectures)

Partial Differential equations, some definitions involving partial differential equations, linear partial differential equations, some important partial differential equations, Method of solving boundary-value problems, General solutions, Separation of variables, Laplace transform nethods.

Suggested Text Books

1. Mickley, Reid and Sherwood, "Applied Mathematics in Chemical Engineering", Tata McGraw Hill, New Delhi (1981).
2. E. Kreyszig, "Advanced Engineering Mathematics", 8th edition, John Wiley and Sons (1999).

Suggested Reference Books

1. M. R. Spiegel, "Advanced Mathematics for Engineers and Scientists", Schaum Outline Series, McGraw Hill, (1971).

TCH 503 ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: To learn advanced topics of classical thermodynamics with emphasis on basic concepts, laws, and thermodynamic relationships and to familiarize students with knowledge of advanced thermodynamics especially in chemical engineering related fields.

Course Outcomes:

Students completing the course will be able to

- CO 1. Perform Legendre transformation of Energy equation and derive Maxwell relations.
- CO 2. Calculate phase equilibrium conditions (BUBL P, BUBL T, DEW T and DEW P) for non ideal mixtures using the gamma-phi approach and the equation of state approach.
- CO 3. Evaluate equilibrium constant and Gibbs free energy change of a chemical reaction by applying criterion of equilibrium.
- CO 4. Calculate the effect of curvature on thermodynamic properties such as vapor pressure and solubility.
- CO 5. Calculate surface excess quantities using Gibbs adsorption equation.
- CO 6. Calculate changes in U, H, and S for ideal gases, and also for non-ideal gases through the use of residual properties
- CO 7. Calculate colligative properties such as Boiling point elevation, freezing point depression
- CO 8. Demonstrate introductory understanding to various concepts of statistical thermodynamics.

Module 1 (12 Lectures)

Introduction to Thermodynamics and statistical mechanics, Internal energy, First law of thermodynamics, Intensive and extensive properties Concept of entropy, Second law of thermodynamics : Extremum principles of Energy and Entropy., Legendre transforms of energy and reformulation of second law in terms of the Legendre transforms, Maxwell relations, Maximum work theorem

Module 2 (10 Lectures)

Conditions of phase equilibrium and its applications, Gibbs Duhem relations, Gibbs phase rule, Conjugate variables, Criteria for stability and its implications. Chemical reactions: condition of equilibrium for a reaction mixture, Equilibrium constants, Heat of reaction Thermodynamics of fluid-fluid interfaces: Dividing surface, surface excess quantities, condition of equilibrium at interfaces, Kelvin equation, Gibbs adsorption isotherm, Thermodynamics of fluid-solid interfaces: condition of equilibrium with respect to dissolution and growth of solids.

Module 3 (8 Lectures)

Classical mechanics: Lagrangian formulation, Constants of motion, Hamilton's principle, and phase space, concept of statistical ensemble, Statistical independence of macroscopic bodies, Liouville equation, Measurements and ensemble averages

Micro-canonical, and Grand-canonical ensembles. Gibbs entropy formula and Boltzmann entropy formula, Partition functions, Fluctuations and stability

Module 4 (5 Lectures)

Ideal gas: Analytical derivations of the partition functions of ideal gas in various ensembles and thermodynamic properties,Ideal solid: Analytical derivation of partition function, heat capacity, Non-ideal gases, Virial equation of state, Second virial coefficient, Liquids: Distribution functions, pair correlation function g(r) and experimental measurement of g(r) by diffraction, Mean-field theory and perturbation theory.

Module 5 (5 Lectures)

Dilute solutions and colligative properties: Derivation of Raoults law, Henry's law, Van't Hoff’s formula for osmotic pressure. Boiling point elevation, freezing point depression Introductory Quantum Statistical mechanics: Schrödinger Wave equation, Degeneracy, Partition functions. Ideal gas of polyatomic particles, Molecular partition functions, Einstein and Debye theory of perfect crystals

Suggested Text Books

1. Herbert B. Callen, "Thermodynamics and an Introduction to thermo statistics", John Wiley and Sons, 1985.
2. D. A. McQuarrie and J. D. Simon, "Molecular Thermodynamics", Viva Books Pvt. Ltd., 2004

Suggested Reference Books

1. David Chandler, "Introduction to modern statistical mechanics", Oxford University Press, 1987.

TCH505 ADVANCED CHEMICAL REACTION ENGINEERING

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

L	T	P	C
4	0	0	4

Course Objectives: To learn the heterogeneous catalyzed reactions and the models involved in reactor design. To appreciate the importance of both external and internal transport effects in gas-solid and liquid-solid systems.

Course Outcomes:

Students completing the course will be able to

- CO 1. Develop basic concepts involved in using reaction rate equations and kinetic constants for homogenous and heterogeneous reactions.
- CO 2. Perform model discrimination and parameter estimation for heterogeneous catalytic reactions.
- CO 3. Predict the role of temperature, concentration and interphase mass transfer in the rate equations.
- CO 4. Derive design equations and perform calculations for various multiphase reactors.
- CO 5. Determine optimal reactor configurations and operating policies for systems involving multiple reactions.
- CO 6. Perform analysis of falling film catalytic wall reactors, trickle bed reactors and chromatographic reactors.

Module 1 (6 Lectures)

Kinetics of heterogeneous catalytic reactions, rate equations, model discrimination and parameter estimation.

Module 2 (7 Lectures)

Deactivating catalysts, mechanisms of catalyst deactivation, the rate and performance equations, design.

Module 3 (7 Lectures)

Mass Transfer and Reaction in a packed bed, Stoichiometric table, Pressure drop in a Reactor, Ergun's equation, Flow through a packed bed.

Module 4 (10 Lectures)

Types of multiphase reactors, mass transfer reactors, mass transfer equations, Interfacial surface area, mass transfer between phases, multiphase reactor equations, equilibrium between phases, membrane reactors, falling film reactors, bubble column reactors.

Module 5 (10 Lectures)

Falling film catalytic wall reactor, trickle bed reactors, multiphase reactors with catalysts, other multiphase reactors, reactor-separator integration, catalytic distillation, chromatographic reactors, iron ore refining, petroleum refinery.

Suggested Text Books

1. O. Levenspiel, "Chemical Reaction Engineering, Wiley India, (1998).
2. G. F. Froment and K. B. Bischoff, "Chemical Reactor Analysis and Design", John Wiley and Sons, (1979).

Suggested Reference Books

1. H. S. Fogler, "Elements of Chemical Reaction Engineering", 2nd edition, Prentice-Hall, (2000).
2. Lanny D. Schmidt, "The Engineering of Chemical Reactions", 2nd edition, Oxford University Press, (2010).

TCH 521/621 AIR POLLUTION MONITORING AND CONTROL

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: To introduce various sources and classification of air pollutants. To understand various methods for air pollution monitoring and learn various dry and wet techniques for air pollution control at source.

Course Outcomes:

Students completing the course will be able to

- CO 1. Demostrate comrehensive understanding of different types of air pollutants and various standards and acts regarding the air pollutants of global concern.
- CO 2. Select proper sampling and analysis method for a specific gaseous or particulate air pollutant.
- CO 3. Analyze plume behavior and come up with a suitable stack design based on meteorological aspects of air pollution.
- CO 4. Select and design the most economical industrial dust collector for control of particulate emission at the source itself.
- CO 5. Design absorption columns for control of gaseous pollutants.
- CO 6. Design three way catalytic converters for pollution control from automobiles.

Module 1 (7 Lectures)

Air Pollutants - Sources and Classification, Effects of air pollutants on physical environment and living systems, Air pollution – Standards and acts, Global consideration of air pollution: Green house effect, Chemical reactions in a contaminated atmosphere, urban air pollution, acid rain.

Module 2 (8 Lectures)

Air pollution monitoring, Sampling and analysis of gaseous and particulate air pollutants, Air pollution control by dilution of contaminants in atmosphere, Atmospheric stability, Lapse rate and Inversion, Meteorological aspects of air pollution: Dispersion models- Gaussian dispersion model, Plume behavior, Stack design.

Module 3 (8 Lectures)

Air Pollution Control at Source - Source Correction methods - Particulate emission control: Dry techniques industrial dust collectors, cyclone and multiclone separators, bag filters, electrostatic precipitators, relative merits and demerits, choice of equipments, design aspects and economics.

Module 4 (9 Lectures)

Wet techniques for controlling particulate pollutants: wet dust collection, wet cyclone, empty scrubber, column (packed) scrubber, venturi scrubber, suitability, merits and demerits, design aspects and economics.

Module 5 (8 Lectures)

Techniques for Controlling Gaseous Pollutants: Absorption - absorbents and absorbers (plate towers and packed towers), Adsorption, Condensation - direct and contact, Combustion - Thermal, flare and catalytic. Pollution control from automobiles - three way catalyst and catalytic converters.

Suggested Text Books:

1. Peavy H.S., Rowe D.R. and Tchobanoglous G., Environmental Engineering, McGraw-Hill edition, 1985
2. M.N. Rao and H.V.N. Rao, "Air Pollution", Tata McGraw Hill, New Delhi, 1993.
3. Rao C.S. "Environmental Pollution Control Engineering," 2nd Edition, New Age
   International Publishers, 2006.

Suggested Reference Books:

1. P. Sincero and G.A. Sincero Environmental Engineering: A Design Approach, PrenticeHall of India pvt Ltd, N.Delhi.1996
2. Y.B.G. Verma, H. Brauer," Air Pollution Control Equipments", Springer, Berlin, 1981

TCH523/623 SAFETY HAZARD AND RISK ANALYSIS

L	T	P	C
4	**0**	**0**	**4**

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: The course is aimed to familiarize the students with the principles of industrial safety and standard safety procedures to be followed in chemical industries. On completion of the course, the students are expected to demonstrate a comprehensive understanding of various accident prevention techniques, hazard analysis techniques and legislations pertaining to safety in chemical industries.

Course Outcomes:

Students completing the course will be able to

CO 1. Identify various types of hazards and risks in a chemical industry.

CO 2. Perform risk analysis by applying various risk assessment techniques.

CO 3. Identify various toxic substances, estimate their toxic limits and suggest protective techniques so that the exposure is within safe limits.

CO 4. Suggest proper ways of handling, transportation and storage of flammable liquids, gases, and toxic materials.

CO 5. Perform disaster planning and management and prepare for any emergency situations.

Module 1 (6 Lectures)

Industrial safety, Industrial hygiene and safety aspects related to toxicity, noise, pressure, temperature, vibrations, radiation etc. Explosions including dust, vapor, cloud and mist explosion.

Module 2 (8 Lectures)

Elements of safety, safety aspects related to site, plant layout, process development and design stages, identification of hazards and its estimation, risk, risk analysis and assessment methods; fault free method, event free method, scope of risk assessment, controlling toxic chemicals and flammable materials.

Module 3 (8 Lectures)

Toxic substances and degree of toxicity, its estimation, their entry routes into human system, their doses and responses, control techniques for toxic substances exposure, use of respirators, ventilation systems.

Module 4 (9 Lectures)

Prevention of losses, pressure relief, provision for fire fighting, release of hazardous materials from tanks, pipes through holes and cracks, relief systems : types and location of relief's.

Module 5 (9 Lectures)

Handling, transportation and storage of flammable liquids, gases, and toxic materials and wastes, regulation and legislation, government role, risk management routines, emergency preparedness, disaster planning and management.

Suggested Text Books:

1. Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with applications, Prentice Hall, Inc, 1990.
2. F. P. Lee's, Loss prevention in the process Industries, Volume 1 and 2 Butterworth, 1983.
3. Hoboken, N. J., Guidelines for Chemical Process Quantitative Risk Analysis, Wiley-Interscience, 2000.

Suggested Reference Books:

1. R. W. King and J. Magid, Industrial Hazards and Safety Handbook, Butterworth, 1982.
2. G. L. Wells, Safety in Process Plant Design, John Wiley and Sons Inc., 1980.
3. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2^{nd} Edition, Wiley-Interscience, New York, 1982.

TCH525/625 INSTRUMENTAL METHODS OF ANALYSIS

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objective:

This course introduces theoretical principles behind modern analytical instrumentation techniques and practical considerations, scope and limitations of each of them.

Course Outcomes:

Students completing the course will be able to

CO 1. Select a suitable method for analysis of a given sample.

CO 2. Analyze the data obtained from any technique to infer meaningful results.

CO 3. Identify the scope and limitations of various techniques.

CO 4. Identify sources of error in each technique and minimize the errors incurred in analysis.

CO 5. Design the instrument for basic parameters testing.

Module 1 (9 Lectures)

Introduction to spectroscopic techniques, UV - Vis Spectrophotometry, Nephelometry, Turbidimetry, Reflectance Spectrometry, Fluorescence, Phosphorescence Spectrometry.

Module 2 (8 Lectures)

Flame Emission and Atomic Absorption Spectrometry, Electro thermal AAS, Hydride generation AAS and Flameless mercury analysis. Inductively Coupled Plasma Atomic Emission Analysis.

Module 3 (9 Lectures)

Infrared spectrometry, Introduction to X-Ray techniques, XRF. Introduction to NMR spectroscopy and mass spectrometry.

Module 4 (7 Lectures)

Electro analytical techniques: Potentiometry, Voltametry, Polarography Chromatographic analysis: GC, LC

Module 5 (7 Lectures)

Chromatographic analysis, HPLC, Hyphenated techniques. Errors, statistical methods of data handling

Suggested Text Books:

1. H.Willard, L.L Meritt, J.A Dean and F.A.Settle: Instrumental Methods of Analysis, 6th Edition, CBS.
2. A.I.Vogel: Quantitative Inorganic Analysis, 5th Edition, ELBS.

Suggested Reference Books:

1. G.W. Ewing: Analytical Instrumentation Hand book, Marcell Dekker, New York, 1990.

TCH527/627 ADVANCED PETROLEUM REFINING

L	T	P	C
4	**0**	**0**	**4**

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: The objective of this course is to understand the chemistry and processes involved in converting the crude oil into valuable products in the petroleum refinery. In addition, the students will gain knowledge with respect to the effects of process variables such as reaction temperature, pressure, space velocity and types of catalyst, etc. on the properties of the products, yield and selectivity.

Course Outcomes:

Students completing the course will be able to

- CO 1. Demonstrate understanding of the past, present and future of petroleum industry nationally and globally.
- CO 2. Determine the quality of crude based on various laboratory characterization techniques.
- CO 3. Explain the processes involved in converting crude oil to various petroleum products.
- CO 4. Select a suitable finishing process based on the nature of crude.
- CO 5. Evaluate and select crude oils for Bitumens and Lube oil manufacturing.

Module 1 (5 Lectures)

Petroleum Exploration Production and Refining of Crude oils, Crude oils: Characteristics and constituents of crude oils, Classification of crude oils.

Module 2 (9 Lectures)

Quality Control of Petroleum Products. Classification of laboratory tests, distillation, vapour pressure, flash and fire points, octane number, performance number, cetane number, aniline point, viscosity index, calorific value, smoke point, char value, viscosity, viscosity index, penetration tests, cloud and pour points, drop point of grease, melting and settling points of wax, softening point of Bitumen, induction period of gasoline, thermal stability of jet fuels, gum content, Total Sulphur, Acidity and Alkalinity,, Copper Strip Corrosion Test, Silver – Strip Corrosion Test for ATF, Ash, Carbon Residue (Conradson method, Ramsbottom method) Colour, Density and Specific gravity, Refractive index of hydrocarbon liquids, water separation index (modified) (WSIM), ductility.

Module 3 (10 Lectures)

Petroleum Products: Composition, Properties & Specification of LPG, Naphthas, motor spirit, Kerosine, Aviation Turbine Fuels, Diesel Fuels, Fuel Oils, Petroleum Hydrocarbon Solvents, Lubricating oils (automotive engine oils, industrial lubricating oils electrical insulating oils, Jute Batching oils, white oils, steam turbine oils, metal working oils, etc.) Petroleum Waxes Bitumens, Petroleum coke. **Crude Oil Distillation**: Desalting of crude oils, Atmospheric distillation of crude oil, Vacuum distillation of atmospheric residue. Thermal Conversion Process: Thermal Cracking Reactions, Thermal Cracking, Visbreaking, (Conventional Visbreaking and Soaker Visbreaking) Coking (Delayed Coking, Fluid Coking, Flexicoking), Calcination of Green Coke.

Module 4 (8 Lectures)

Catalytic Conversion Process: Fluid catalytic cracking; Catalytic reforming; Hydrocracking Catalytic Alkylation, Catalytic Isomerization; Catalytic Polymerization.

Finishing Process: Hydrogen sulphide removal processes; Sulphur conversion processes; Sweetening processes (Caustic treatment, Solutizer process; Doctor treating process; Copper chloride sweetening,; Hypochlorite sweetening ;Air and inhibitor treating process; Merox processes;Sulphuric acid treatment; Clay treatment); Solvent extraction processes (Edeleanu process, Udex process, Sulfolane process), Hydrotreating processes.

Module 5 (8 Lectures)

Lube Oil Manufacturing Process: Evaluation of crude oils for lube oil base stocks, Vacuum distillation, Solvent deasphalting Solvent extraction of lube oil fractions (Furfural, NMP and Phenol), Solvent dewaxing, Hydrofinshing, Manufacture of petroleum waxes (Wax sweating, Solvent deoiling)

Manufacture of Bitumens: Selection of crude oil, Methods of manufacture of bitumens, (Distillation, Solvent precipitation, Air blowing).

Suggested Text Books

1. Nelson, W.L., Petroleum Refining Engineering, McGraw Hill

2. Mall. I.D., Petroleum Refining Technology", CBC Publishers.

Suggested Reference Books

1. Mall I. D., Petrochemical Process Technology", CBC Publishers.

2. Ram Prasad, Petroleum Refining Technology, Khanna Publishers, Delhi (2000)

TCH 502 ADVANCED TRANSPORT PHENOMENA

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objective: The course will accustom the students with import topics in advanced transport phenomena (momentum, heat and mass transport). The Focus will be to develop physical understanding of principles discussed and with emphasis on chemical engineering applications. In addition to the text, the student will be exposed to classic and current literature in the field.

Course Outcome:

Students completing the course will be able to

CO 1. Set up and solve differential momentum, heat, and mass balances for 1-D steady state problems and quasi-steady-state problems occurring in laminar and turbulent flows in terms of vector and tensor fluxes.

CO 2. Formulate conservation statements in heat, mass, and momentum at multiscales from microscopic to macroscopic in both steady and unsteady modes.

CO 3. Analyze advanced transport problems in heat, mass, and momentum, both macroscopic and microscopic, formulate simultaneous energy and mass balances in chemical processes.

Module 1 (6 Lectures)

Philosophy and fundamentals of three transport phenomena : Importance of transport phenomena; analogous nature of transfer process; basic concepts, conservation laws. Molecular transport of momentum, Heat and mass, laws of molecular transport, Newton’s law of viscosity, Fourier law of heat conduction, and Fick’s law of diffusion. Transport coefficients – viscosity, thermal conductivity and mass diffusivity. Estimation of transport coefficients and temperature / pressure dependence.

Module 2 (8 Lectures)

one dimensional transport in laminar flow (shell balance) :Newtonian and non-Newtonian fluids, General method of shell balance approach to transfer problems; Choosing the shape of the shell; most common boundary conditions; momentum flux and velocity distribution for flow of Newtonian fluids in pipes, for flow of Newtonian fluids in planes, slits and annulus, Time derivatives, The equation of continuity, the equation of motion, the equations of change in curvilinear, co-ordinates, use of the equations of change to set up steady flow problems.

Module 3 (9 Lectures)

Unsteady state momentum transport, Flow near a wall suddenly set in motion, Momentum transport phenomena in turbulent flow. Definitions of friction factors, friction factor for flow in tubes, for flow around spheres, for packed bed column.

Module 4 (9 Lectures)

shell energy balance, boundary conditions, Heat conduction with an electrical heat source, Heat conduction in a cooling fins, heat conduction with exothermic reactions. Temperature distributions with more than one independent variables: Unsteady state heat conduction in solids, Boundary layer theory.

Module 5 (8 Lectures)

Definitions of concentrations, velocities & mass fluxes, Fick's law of diffusion, Temperature & pressure dependence of mass diffusivity, Maxwell’s law of diffusion.shell mass balance, boundary conditions, diffusion through a stagnant gas film. Diffusion with heterogeneous chemical reaction, Diffusion with homogeneous chemical reaction, Diffusion in to a falling liquid film.

Suggested Text Books:

1. Transport Phenomena,R.B. Bird, W.E. Stewart and E.W. Lighfoot, 2nd Edition. John Wiley, 2002
2. Fundamentals of Momentum Heat and Mass Transfer, J.R. Wilty, R.W. Wilson, and C.W. Wicks, 4th Edition, John Wiley, New York, 2001

Suggested Reference Books:

1. Transport Processes and Separation Process Principles, Christie J. Geankopolis, 4th Edition. Printice-Hall, 2003
2. "Transport Phenomena – A Unified Approach", R.S. Brodkey, and H.C. Hershey, McGraw Hill, 1988

TCH 504 ADVANCED SEPARATION PROCESSES

L	T	P	C
4	**0**	**0**	**4**

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: To learn the principle and technical concept of advanced separation processes. Create awareness among students with new and unconventional separation processes, Acquire sufficient knowledge in energy intensive processes for separation of components, Students will be equipped with the applications in Down-streaming processes

Course Outcome:

Students completing the course will be able to

CO 1. Analyze multicomponent distillation using shortcut methods.

CO 2. Calculate the enhancement factor for absorption with chemical reactions and estimate the effect of reversibility of chemical reaction on the mass transfer rate.

CO 3. Select a suitable membrane for a given separation process and determine the effect of process variables on gas separation by membranes.

CO 4. Analyze the effect of process variables on Reverse osmosis membrane processes and Ultrafiltration membrane processes.

CO 5. Explain Supercritical fluid extraction, Supercritical fluid chromatography, and Supercritical fluid reactions.

Module 1 (5 Lectures)

Fundamentals of separation process, Review of Distillation, Multi component distillation – Bubble point and dew point calculations and Short cut methods, Azeotropic distillation; Extractive distillation; Molecular distillation; Reactive distillation

Module 2 (8 Lectures)

Absorption with chemical reaction; Enhancement factor; Simultaneous diffusion and chemical reaction near an interface – Film theory, Penetration theory, Surface renewal theory Surfactant based separation processes: Liquid membranes: fundamentals and modeling. , Micellar enhanced separation processes, Cloud point extraction.

Module 3 (8 Lectures)

Supercritical fluid extraction – Supercritical fluids, Phase equilibria, Industrial applications; Important supercritical processes – Decaffination of coffee, Extraction of oil from seeds, Residuum oil supercritical extraction (ROSE), Supercritical fluid chromatography, Supercritical fluid reactions etc. Centrifugal Separation processes chromatographic separation processes

Module 4 (10 Lectures)

Classification of membrane processes; Liquid permeation membrane processes or dialysis – Series resistance in membrane processes, Dialysis processes, Types of equipment for dialysis; Gas permeation membrane processes – Types of membranes and permeabilities for separation of gases, Types of equipment for gas permeation membrane processes (flat membranes, spiral-wound membranes, hollow-fibre membranes); Types of flow in gas permeation; Complete-mixing model, cross-flow model and countercurrent flow model for gas separation by membranes; Effect of processing variables on gas separation by membranes

Module 5 (9 Lectures)

Reverse osmosis membrane processes – Osmotic pressure of solution, flux equation, Types of equipment and Complete mixing model; Effect of operating variables; Concentration polarization; Permeability constants

Ultrafiltration membrane processes – Types of equipment, flux equation, effects of processing variables

Suggested Text Books:

1. C.J.Geankoplis, Transport Processes and Unit Operations, Prentice-Hall of India Pvt. Ltd., New Delhi (2000).

2. T.K.Sherwood, R.L.Pigford and C.R.Wilke, Mass Transfer, McGraw-Hill, New York (1975).

Suggested Reference Books:

1. R.E.Treybal, Mass-Transfer Operations, McGraw-Hill, New York (1980).
2. Latest articles from journals

TCH 506 OPTIMIZATION OF CHEMICAL PROCESSES

L	T	P	C
4	**0**	**0**	**4**

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objective: To understand the concepts and origin of the different optimization methods. To get a broad picture of the various applications of optimization methods used in Chemical Engineering. Optimizes different methods in industry for design and production, both economically and efficiently.

Course Outcome:

Students completing the course will be able to

- CO 1. Demonstrate comprehensive understanding of various optimization techniques. Formulate various process optimization problems.
- CO 2. Explain the need for optimization where optimal decisions need to be taken in the presence of trade-offs between two or more conflicting objectives.
- CO 3. Implement the theory and applications of optimization techniques in a comprehensive manner for solving linear and non-linear, geometric, dynamic, integer and stochastic programming techniques.
- CO 4. Identify, formulate and solve a practical engineering problem of their interest by applying or modifying an optimization technique.

Module (7 Lectures)

Introduction to process optimization; formulation of various process optimization problems and their classification, Basic concepts of optimization-convex and concave functions, necessary and sufficient conditions for stationary points.

Module 2 (10 Lectures)

Optimization of one dimensional functions, unconstrained multivariable optimization-direct search methods. Bracketing methods: Exhaustive search method, Bounding phase method Region elimination methods: Interval halving method, Fibonacci search method, Golden section search method. Point-Estimation method: Successive quadratic estimation method. Indirect first order and second order method. Gradient-based methods: Newton-Raphson method, Bisection method, Secant method, Cubic search method. Root-finding using optimization techniques.

Module 3 (7 Lectures)

Multivariable Optimization Algorithms: Optimality criteria, Unidirectional search, direct search methods: Evolutionary optimization method, simplex search method, Powell's conjugate direction method. Gradient-based methods: Cauchy's (steepest descent) method, Newton's method. Constrained Optimization Algorithms: Kuhn-Tucker conditions, Transformation methods: Penalty function method, method of multipliers, Direct search for constraint minimization: Variable elimination method, complex search method.

Module 4 (6 Lectures)

Linear Programming: Graphical solution, Primal Simplex method, Artificial starting solution, Dual Simplex method, Primal-Dual relationship, Duality, Sensitivity analysis. Revised Simplex method.

Module 5 (10 Lectures)

Transportation Problem, Optimization of staged and discrete processes. Dynamic programming, Specialized & Non traditional optimization techniques: Simulated annealing; Genetic algorithms; Differential evolution. Application of optimization in the design of separation process, chemical reactor and large scale process plant.

Suggested Text books:

1. T.F.Edgar and D.M.Himmelblau, "Optimization of Chemical Processes", Mc Graw Hill, International editions, chemical engineering series, 1989.
2. G.S. Beveridge and R.S. Schechter, "Optimization theory and practice", Mc Graw Hill, Newyork, 1970.
3. Hamdy A. Taha, " Operation Research", Pearson, 2008

Suggested Reference Books:

1. Rekllitis, G.V., Ravindran, A., and Ragdell, K.M., Engineering Optimization-Methods and Applications, John Wiley, New York, 1983.
2. Latest articles from journals

TCH 522/622 ADVANCED PROCESS CONTROL

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

L	T	P	C
4	0	0	4

Course Objective: The main purpose of teaching Process Dynamics and Control as elective-II for M. tech second year postgraduate students is to make them understand the unity in outlook that has been lacking in the field of chemical reactor design. The stability viewpoint does in a sense in diverse areas like stirred tank reactor, plug flow reactor. The course in common emerge as qualitative description of the behavior of the respective models, for the stability viewpoint deals with certain structural aspects present in both problems.

Course Outcome:

Students completing the course will be able to

CO 1. Understand about the most common chemical reactor models. The subject of steady state multiplicity in stirred tank reactors and develops uniqueness criteria for various cases that may be of interest for design.

CO 2. Understand the terms such as steady and stable. The students should apply the knowledge to explore the implications of the stability concept in dealing with finite disturbances of practical magnitude.

CO 3. Analyze from ordinary differential equation models to partial differential equation models.

CO 4. Apply the knowledge of steady state multiplicity, local stability, and regional stability are treated for distributed systems.

Module 1: (8 Lectures)

Introduction to process dynamics (first and second order process), Block diagram preparation of control system, various modes of control action, Stability, Characteristic equation, Routh-Hurwitz criterion for stability. Root locus Analysis, Frequency response, Bode stability criterion, Bode diagrams, Nyquist stability criterion, Nyquist plots, and Frequency response of closed loop systems

Module 2: (8 Lectures)

Outline of the design problems. Simple Performance criteria, Time-integral performance criteria, Selection of the type of feedback controllers. Designing of Feedback Controllers by Frequency Response Techniques. Gain and Phase margins, Controller tuning, Zeigler – Nichols Tuning technique, Cohen and Coon tuning method, Smith Predictor for dead-time compensation

Module 3: (8 Lectures)

Cascade control, Design of Cascade controllers, Various types of selective control-Auctioneering and Override control, Split range control, Feed forward control, Ratio control

Module 4: (8 Lectures)

Adaptive and inferential control, Concept of discretization and Z-transforms, Introduction to digital control

Module 5: (8 Lectures)

Control configuration for multi-input and multi-output processes, State space representation of physical systems, Interaction and decoupling

Suggested Text Books:

1. Coughnower, "Process Systems Analysis and Control". McGraw Hill, Singapore, Second Edition, 1991.
2. George Stephanopoulose, **"**Chemical Process Control, An Introduction to Theory and Practice", Prentice Hall of India, New Delhi 1999.

Suggested Reference Books:

1. W. L. Luyben, "Process Modeling, Simulation and Control for Chemical Engineers", McGraw Hill Singapore, 1990.

TCH 524/624 STATISTICAL DESIGN OF EXPERIMENTS

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: The aim of the course is to give competences in the field of applied statistical methods for work concerning planning and analysis of experiments, regression analysis, optimization of processes and multivariate analysis.

Course Outcome:

Students completing the course will be able to

- CO 1. Understand the importance of randomization and replication of experimental data set.
- CO 2. Estimate statistical variance and perform analysis of variance, regression analysis, correlation analysis on a given experimental data
- CO 3. Design full factorial and fractional factorial experiments and analyse the data
- CO 4. Develop nested designs, block designs and response surface designs
- CO 5. Recognize what design was followed and perform the appropriate analysis given the description of how a set of data was collected.

Module 1 (7 Lectures)

Introduction to statistics for engineers: Simplest discrete and continuous distributions, Statistical inference, Statistical estimation, tests and estimates on statistical variance, Analysis of variance, Regression analysis (Simple linear, multiple, polynomial, nonlinear), Correlation analysis (Correlation in linear regression, correlation in multiple linear regression)

Module 2 (8 Lectures)

Design and analysis of experiments: Introduction to design of experiments, Preliminary examination of subject of research, Screening experiments

Basic experiment-mathematical modeling: Full factorial experiments and fractional factorial experiments, Second-order rotatable design (Box-Wilson design).

Module 3 (9 Lectures)

Orthogonal second order design (Box Benken design), D-optimality, B_k-designs and Hartleys second order design.

Statistical analysis: Determination of experimental error, Significance of the regression coefficients, Lack of fit of regression models

Module 4 (7 Lectures)

Experimental optimization of research subject: Problem of optimization, Gradient optimization method, canonical analysis of response surface.

Module 5 (9 Lectures)

Mixture design `composition-property: Screening design `composition-property', Simplex lattice design, Scheffe simplex lattice design, Simplex centroid design, Extreme vertices design, D-optimal design, Draper-Lawrence design, Factorial experiments with mixture, Full factorial combined with mixture design

Suggested Text Books:

1. Z.R.Lazic, Design of experiments in chemical engineering: A practical guide, Wiley (2005).

TCH 526/626 DESIGN OF PIPING SYSTEM FOR CHEMICAL PLANTS

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objective: This course covers various aspects of designing a piping system for a chemical plant. This includes selection of the type, size and material of pipes and various fittings. Course also deals with piping layout and its installation.

Course Outcome:

Students completing the course will be able to

- CO 1. Calculate pressure drop for Newtonian & non-Newtonian fluids, incompressible & compressible fluids and two-phase flows.
- CO 2. Calculate economic pipe diameter and optimum insulation thickness for a given fluid flow.
- CO 3. Calculate stresses in a curved pipe line or in a bend.
- CO 4. Select proper type and material of joints, valves, bolts, gaskets and other fittings for a given fluid.
- CO 5. Design piping layout around a given equipment and for the whole plant.

Module 1 (6 Lectures)

Fundaments of fluid flow through pipes-Calculation of pressure drop for Newtonian & non-Newtonian fluids, incompressible & compressible fluids and two-phase flow,

Module 2 (7 Lectures)

Calculation of Economic pipe diameter, insulation thickness, equivalent length, Slurry transport and pipelines

Module 3 (10 Lectures)

Engineering flow diagram, nomenclature and equipment elevation

Piping layout, line pressure drop, piping analysis, stress analysis of curved pipelines, yard piping Piping codes, standards and specifications-ASME, ASTM, API

Module 4 (9 Lectures)

Piping components-pipes, pipe ends, pipe fittings, end fittings, flanged joints, valves, valve codes and standards, valve classification, valve components, bolts, gaskets (fasteners and sealing elements)Piping materials-selection, cost and installation

Module 5 (8 Lectures)

Design of heat exchanger piping, Thermosyphon reboiler piping, Pressure relief piping Steam tracing design, Thermowell design, Expansion loops and expansion joints Design of pipeline network-Pinch analysis Pipeline operation and maintenance-friction reduction, cleaning, coating, wear, leak detection, water hammer.

Selected Text Books:

1. Peter Smith, Fundamentals of piping design, Gulf Publishing House

Selected Reference Books:

1. Kellog, Design of pipeline systems

TCH 528/628 WATER POLLUTION MONITORING AND CONTROL

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objective:

To study methods of monitoring water pollution from various sources and characterize waste water based on its constituent pollutants. Learn ways to reduce BOD and COD and design a waste water treatment plant covering various physical, chemical and biological processes routinely used. Advanced treatment options utilizing ion exchange and membrane separation will also be covered. Students will be introduced to schemes for treatment of some typical industrial wastes from pulp and paper, sugar, distillery, dairy, fertilizer, refinery etc.

Course Outcome:

Students completing the course will be able to

- CO 1. Isolate specific sources of water pollution and monitor the levels so that they comply with minimum national standards.
- CO 2. Design a waste water treatment plant for given reduction in BOD and COD.
- CO 3. Design plant for treatment and disposal of sludge.
- CO 4. Select advanced treatment options based of waste water characteristics.
- CO 5. Explain how the effluents from different industries are treated.

Module 1(9 Lectures)

Water Pollutants, Effects, Monitoring and Quality standards: Pollution of water and soil, effect of pollutants on environment and health, monitoring water, pollution, water pollution laws and minimum national standards, monitoring, compliance with standards, Latest norms for effluent treatment.

Module 2(8 Lectures)

Water Pollution Sources, Analysis and Methods of control: Water pollution sources and classification of water pollutants - Wastewater sampling and analysis. Treatment of water-pollution: BOD, COD of wastewater and its reduction – Fundamentals of Anaerobic digestion and Aerobic digestion.

Module 3 (8 Lectures)

Wastewater Treatment Plant Design: Physical unit operations: Screening, Flow equalization, sedimentation etc., Chemical Unit Processes: chemical precipitation, dis-infection, color removal by adsorption Biological unit processes: Aerobic suspended - growth treatment processes, aerobic attached growth treatment processes, anaerobic suspended - growth treatment processes, Anaerobic attached-growth treatment processes.

Module 4(7 Lectures)

Advanced Wastewater and Water Treatment: Carbon adsorption - Ion exchange- Membrane processes - Nutrient (nitrogen and phosphorus) removal - Design of plant for treatment and disposal of sludge.

Module 5 (8 Lectures)

Water pollution legislation and regulation. Schemes for treatment of some typical industrial wastes – pulp and paper, sugar, distillery, dairy, fertilizer, refinery etc.

Suggested Text Books:

1. C.S. Rao, "Environmental Pollution Control Engineering", Wiley 2nd Edition, New Age International Publishers, 2006.
2. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi, 1985

Suggested Reference Books:

1. P. Sincero and G.A. Sincero, Environmental Engineering: A Design Approach Prentice Hall of India pvt Ltd, N.Delhi.1996
2. Tchbanoglous and F.L. Burton, Metcalf and Eddy’s Wastewater Treatment- Disposal And Reuse (Third Ed.), TMH publishing Co Ltd, N. Delhi

TCH 601 MODELING AND SIMULATION OF CHEMICAL PROCESSES

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objective:

To give an overview of various methods of process modeling, different computational techniques for simulation. The focus shall be on the specific applications so that the student can take up modeling and simulation challenges in his profession.

Course Outcome:

CO 1. Select the type of model to be used based on the problem. That is make a selection simple vs. rigorous model, lumped parameter vs. distributed parameter, Steady state vs. dynamic, Transport phenomena based vs. Statistical models.

CO 2. Development of process models based on conservation principles and process data

CO 3. Develop steady state models for various heat transfer and mass transfer equipments.

CO 4. Develop mathematical models of Batch reactors, Continuous-stirred tank reactors and Plug-flow reactors

CO 5. Demonstrate the knowledge of various simulation packages and available numerical software libraries.

Module 1 (10 Lectures)

Fundamentals of mathematical modeling-Principles of formulations, Fundamental laws: Continuity equations, energy equation, equation of motion, transport equations, equation of state, equilibrium, chemical kinetics; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models-Simple vs. rigorous, lumped parameter vs. distributed parameter, Steady state vs. dynamic, Transport phenomena based vs. Statistical; Concept of degree of freedom for steady state and unsteady state systems.

Module 2 (8 Lectures)

Mathematical models of heat-transfer equipments: Double pipe heat exchanger, Shell & tube heat exchangers, Evaporators, Fired heaters, Partial condensers

Module 3 (6 Lectures)

Mathematical models of mass-transfer equipments: Batch and continuous distillation columns, Reactive distillation columns, packed absorption columns, Dehumidifiers

Module 4 (8 Lectures)

Mathematical models of reactors: Batch reactors, Continuous-stirred tank reactors, Plug-flow reactors, Industrial reactors-Ammonia converter, Sulphuric acid converter, Methanol reactor, FCC reactor, Claus reactor, etc.

Module 5 (8 Lectures)

Numerical methods: Linear and non-linear simultaneous algebraic equations, Ordinary-differential equations-Initial-value problems & boundary-value problems, Partial-differential equations Different approaches to flow sheet simulation-Sequential modular approach, Simultaneous modular approach, Equation oriented approach; Review of thermodynamic procedures and physical property data banks.

Suggetsed Text Books:

1. Luyben, W.L., “Process Modeling, Simulation, and Control for Chemical Engineering”, Wiley.
2. M.M. Denn, “Process Modelling”, Wiley, New York, (1990).
3. Hussain Asghar, “Chemical Process Simulation”, Wiley Eastern Ltd., New Delhi, (1986)
4. C.D. Holland and A.I. Liapis, “Computer Methods for Solving Dynamic Separation Problems”, McGraw Hill, (1983).

Suggested Reference Books:

1. C.D. Holland, “Fundamentals of Modelling Separation Processes”, Prentice Hall, (1975)
2. S.M. Walas, “Modelling with Differential Equations in Chemical Engineering”, Butterworth, (1991)

TCH631/731 PRINCIPLES OF POLYMER ENGINEERING

L	T	P	C
4	**0**	**0**	**4**

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: To provide an opportunity for post graduate students to develop skills, strategies and methods necessary to understand the basic principles dynamics of polymers in solution through various models.

Course Outcome:

Students completing the course will be able to

- CO 1. Describe flow behavior of polymer melts and solutions (dilute and semi-dilute)
- CO 2. Review and distinguish between the models for polymer solutions.
- CO 3. Select suitable polymer for a given application
- CO 4. Select a suitable reinforcement material for blending with plastics in order to improve their mechanical properties.
- CO 5. Select a suitable processing and manufacturing technique for a given polymer.

Module 1 (8 Lectures)

Addition polymers, Condensation polymers, Copolymers, Cross-linked polymers, Molecular symmetry and the tendency to form crystals, Distribution of relative molecular mass, Structure of the crystal, Crystal shape, Crystallinity, Crystallization and melting, the glass transition temperature, Molecular conformation in the amorphous polymer, the freely jointe chain, the Gaussian chain, Molecular orientation.

Module 2 (8 Lectures)

Structure of an ideal rubber, Entropy elasticity, elasticity of a network, Stress-strain relationship, Engineering rubbers, The nature of viscoelasticty, Creep, Stress relaxation, Dynamic properties, Theory of linear viscoelasticity, Polymer selection:stiffness.

Module 3 (8 Lectures)

Yielding, Crazing, Linear elastic fracture mechanics, Elastic-plastic fracture mechanics, Brittle fracture of polymer, rubber toughening, Reinforced plastics, Forming of reinforced plastics, the mechanics of fibre reinforcement, Reinforced rubbers.

Module 4 (8 Lectures)

The flow properties of polymer melts, Cooling and solidification, Extrusion, Injection moulding, Compression and transfer moulding.

Module 5 (8 Lectures)

Materials selection, Designing for manufacture, Designing for stiffness, Designing for strength, Case Histories.

Suggested Text Books

1. N. G. McCrum, C. P. Buckley and C. B. Bucknall, Principles of Polymer Engineering, 2nd Edition, Oxford University Press, (1997).

TCH633/733 SOLAR THERMAL ENERGY STORAGE

L	T	P	C
4	0	0	4

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives: To emphasize the importance and modes of energy storage in the form of sensible heat storage, latent heat storage and chemical energy storage.

Course Outcome:

Students completing the course will be able to

CO 1. Explain the quality of energy and modes of energy storage.

CO 2. Understand how energy is stored as sensible heat and latent heat.

CO 3. Select chemical energy storage system based on thermodynamic considerations, reversibility, reaction rates, controllability, ease of storage, safety, availability and cost, product separation, catalyst availability and lifetime.

CO 4. Explain the construction and working of a long term energy storage.

Module 1 (7 Lectures)

Importance and modes of energy storage; Size and duration of storage; Applications-Stationary, transport; Quality of energy and modes of energy storage; Thermal energy storage, Mechanical energy storage, Electrical and magnetic energy storage, Chemical energy storage

Module 2 (5 Lectures)

Sensible heat storage: Basics, Sensible heat storage media; Well-mixed liquid storage; Stratified liquid storage; Containers for water storage; Packed bed storage system

Module 3 (9 Lectures)

Latent heat or phase change thermal energy storage: Basics of latent heat storage-Heat of fusion, Employment of latent heat storage system; Liquid-solid transformation; Phase change materials (PCM); Selection of PCM; Storage in salt hydrates, Prevention of incongruent melting and thermal cycling; Storage in paraffins; Heat transfer in PCM; Heat exchange arrangement and containment of PCM; Storage in PCM undergoing solid-solid transition; Heat of solution storage and heat exchangers.

Module 4 (9 Lectures)

Chemical Energy Storage: Selection criterion-Thermodynamic considerations, Reversibility, Reaction rates, Controllability, Ease of storage, Safety, Availability and cost, Product separation, Catalyst availability and lifetime; Energy storage in thermal dissociation type of reactions; Methane based reactions; Heat transformations and chemical heat pumps; Three step approach; Energy storage by adsorption

Module 5 (10 Lectures)

Long-term energy storage; Solar ponds-Construction, Working, Applications; Energy storage in aquifers; High temperature heat storage; Testing of thermal energy storage systems.

Suggested Text Books:

1. H.P.Garg, S.C.Mullick and A.K.Bhargava, Solar Thermal Energy Storage, D.Reidel Publishing Company, Dordrecht ((1985).

TCH635/735 NANO TECHNOLOGY

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

L	T	P	C
4	0	0	4

Course Objectives: This course aims to provide a broad overview of fundamental principles and laws governing the properties at nanometer scale. Students will learn various top down and bottom up approaches for nanostructure synthesis and experimental techniques to characterize them. This course will also introduce various applications of nanotechnology in chemical engineering.

Course Outcomes:

Students completing the course will be able to

CO 1. Describe the basic science behind the novel properties of materials at the nanometer scale.

CO 2. Demonstrate a comprehensive understanding of the state of the art nanofabrication methods.

CO 3. Compare and select suitable techniques for characterization of a given nanomaterial.

CO 4. Explain how nanotechnology can be put to use in varied areas of science and engineering.

CO 5. Evaluate the impact of nanotechnology on society and environment.

CO 6. Evaluate current constraints such as regulatory, ethical, political, social and economical; when putting nanotechnology to use.

Module 1 (8 Lectures)

Introduction to Nanotechnology - its emergence and challenges, Nanomaterials and its classification, Properties of individual nanoparticles, Methods of synthesis, Reactivity of nanoparticles, List of stable carbon allotropes extended, Synthesis of carbon buckyballs, fullerenes, metallofullerenes, solid C60, bucky onions, nanotubes, nanowires, nanocones, Carbon nanostructures

Module 2 (8 Lectures)

Synthesis procedures of nanomaterials Methods of Synthesis of Nanomaterials: Bottom-up (building from molecular level) and top-down (breakdown of microcrystalline materials) approaches. Manufacturing of nanoscale materials: Chemical vapor deposition of carbon nano tubes, Plasma deposition of ultra thin functional films on nano materials, Solution based Synthesis of Nanoparticles, Vapour Phase Synthesis & Synthesis with framework, Nanolithography, Dip Pen Lithography. Artificially Layered Materials: Quantum Well, Quantum Dots, Super lattices & Layered Structures.

Module 3 (8 Lectures)

Characterizations of nanomaterials. Top down approach vs Bottom up approach, Optical Microscopy, Electron Microscopy, Secondary electron scattering, back scattering, Scanning Probe Microscopes, Focussed Ion Beam Technique, X-ray imaging, Transmission Electron Microscope (TEM), Scanning Probe Microscope (SPM)- Atomic Force Microscope (AFM), Scanning Tunneling Microscope (STM).

Module 4 (8 Lectures)

Nano colloids and Chemistry. Surface Tension and Interfacial Tension, Surfaces at Equilibrium, Surface Tension Measurement, Contact Angles, Colloidal Stability, Electrical Phenomena at Interfaces, Vander Waals Forces between Colloidal Particles, Photocatalysis Nanostructured materials, Self-assembly and Catalysis.

Module 5 (8 Lectures)

Commercial Processes for Nanotechnology and Chemical Engineering Applications. Nanobiotechnology : Drug Delivery, Nanoclay, Nanocomposites, Surface coatings, Self cleaning Materials, Hydrophobic Nanoparticles, Biological nanomaterials, Nanoelectronics, Nanomachines & nanodevices, Nanohydrogel, Photocatalytic reactors, Nanoclay Synthesis, Polymer nanocomposite, Waste Water Treatment, Societal, Health and Environmental Impacts, Introduction to industries which produces commercial nanomaterials.

Suggested Text Books:

1. G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao, Introduction to NanoScience, CRC Press of Taylor and Francis Group, 2008

2. Pools C.P. and Owens F.J., Introduction to Nanotechnology, Wiley-Interscience, 2003

Suggested Reference Books:

1. Bhusan B., Springer Handbook of Nanotechnology

TCH637/737 **NATURAL GAS ENGINEERING**

L	T	P	C
4	**0**	**0**	**4**

Assessment:

Sessionals: 50 marks

End Semester: 50 marks

Course Objectives:

This course deals with the estimation of gas reserves and harnessing of natural gas. To study gas dehydration and processing and steady state flow of gas through pipes

Course Outcome:

Students completing the course will be able to

CO 1. Explain the estimation of gas reserves and non-associated gas reserves.

CO 2. Understand hydrate thermodynamics and formation kinetics.

CO 3. Determine water content in gas and suggest suitable dehydration method.

CO 4. Design procedures for absorbtion, adsorption and membrane separation for gas processing

CO 5. Determination temperature/ pressure for hydrate formation.

Module 1 (6 Lectures)

Introduction: Estimation of gas reserves and non-associated gas reserves.

Properties:Phase behaviour fundamentals, properties of natural gas, gas and liquid separation.

Module 2 (8 Lectures)

Natural Gas Hydrates,Natural gas hydrates, hydrate thermodynamics and formation kinetics, hydrate exploitation.

Module 3 (8 Lectures)

Gas Dehydration,Gas-water system, water content determination, glycol dehydration, solid bed dehydration.

Acid Gas Treating: Gas sweetening processes, solid bed adsorption, chemical and physical solvent processes, desulphurization, membrane separation.

Module 4 (10 Lectures)

Gas Processing, Absorption, refrigeration, fractionation and design consideration, design procedures for absorbtion, adsorption and membrane separation.

Module 5 (8 Lectures)

Gas Hydrates, Determination of hydrate formation temperature/ pressure, condensation of water vapor, temperature drop due to gas expansion, thermodynamic inhibitors, kinetic inhibitors and anti agglomerates.

Gas Engineering, Steady state flow of gas through pipes.

Suggested Text Books:

1. William C. L., “Standard Handbook of Petroleum and Natural Gas Engineering”, Vol. 2, 6th Ed., Gulf Publishing Company. 2001
2. Arnold K. and Steward M., “Surface Production Operations: Design of Gas Handling Systems and Functions”, Butter Worth Heinemann. 1999

Suggested Reference Books:

1. Molhatab S., Poe W. A. and Speight J. G., “Handbook of Natural Gas Processing and Transmission”, Gulf Publishing Company2006
2. Kidney A. J. and Prvish W. R., “Fundamentals of Natural Gas Processing”, CRC. 2006