JK Lakshmipat University

Laliya Ka Vas, P.O. Mahapura, Ajmer Road, Jaipur 302 026

Ph.: +91-141-7107500/504

INSTITUTE OF ENGINEERING AND TECHNOLOGY

4 Year B. Tech Program

(Branch: Chemical Engineering)

Batch 2014-18

Course Structure, Detailed Syllabus

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Scheme of Examination

JK Lakshmipat University, Jaipur
Institute of Engineering and Technology
Department of Chemical Engineering
Course Structure for the Batch 2014 – 18

Sem	Courses								(L T P) Credits Hrs/Week
I	English Communication Skills	Engineering Mathematics - I	Engineering Physics	Electrical & Electronics Engineering	Engineering Mechanics	Engineering Drawing			(16 4 6) 23
	LA101 (2 1 0) 3	MA101 (3 1 0) 4	PH101 (3 1 2) 5	EE101 (3 0 2) 4	ME201 (3 1 0) 4	CE102 (2 0 2) 3			26
II	Professional Communication Skills	Engineering Mathematics - II	Engineering Chemistry	Environmental Studies	Workshop Practice	Computer Programming			(12 3 9) 19.5
	LA201 (1 1 2) 3	MA201 (3 1 0) 4	CH101 (3 1 2) 5	ID201 (2 0 0) 2	ME141 (0 0 3) 1.5	CSE201 (3 0 2) 4			24
III	Chemical Process Calculations	Fluid Flow Operations	Heat Transfer Operations	Unit Processes in Organic Synthesis	Engineering Mathematics – III	Principles of Management for Engineers	Object Oriented Programming		(20 4 7) 27.5
	CHE301 (3 1 0) 4	CHE302 (3 1 2) 5	CHE303 (3 1 3) 5.5	CHE304 (3 0 0) 3	MA301 (3 1 0) 4	HS302 (2 0 0) 2	CSE302 (3 0 4) 5		31
IV	Chemical Reaction Engineering - I	Mass Transfer Operations	Chemical Engineering Thermodynamics	Mechanical Operations	Numerical & Statistical Methods	Fuel and Combustion Technology			(18 4 8) 26
	CHE404 (3 1 0) 4	CHE402 (3 1 3) 5.5	CHE403 (3 1 0) 4	CHE405 (3 1 3) 5.5	MA402 (3 0 2) 4	CHE406 (3 0 0) 3			30
V	**Practice School - I (PS 501) - 4 to 6 Weeks Duration - 4 Credits**								
	Chemical Reaction Engineering - II	Process Dynamics & Control	Process Modeling and Simulation	Separation Processes	Process Instrumentation	Chemical Engineering Materials			(18 4 7) 25.5+4
	CHE501 (3 1 3)5.5	CHE502 (3 1 2) 5	50CHE503 (3 1 2) 5	CHE504 (3 1 0) 4	CHE506 (3 0 0) 3	CHE505 (3 0 0) 3			29
VI	Computational Fluid Dynamics	Chemical Process Technology	Process Equipment Design	Transport Phenomena	Elective – I	Elective – II			(18 3 5) 23.5
	ME625 (3 0 2) 4	CHE602 (3 0 0) 3	CHE603 (3 1 3) 5.5	CHE604 (3 1 0) 4	(3 0 0) 3	(3 1 0) 4			26
VII	Optimization of Chemical Processes	Process Utility and Industrial Safety	Industrial Pollution Abatement	Elective – III	Elective – IV	Seminar	Principles of Economics		(18 3 6) 24
	CHE701 (3 1 0) 4	CHE 702 (3 1 0) 4	CHE 703 (3 0 2) 4	(3 1 0) 4	(3 0 0) 3	SEM701 (0 0 4) 2	HS701 (3 0 0) 3		27
VIII	**Practice School - I (PS 801) - 16 Weeks Duration - 16 Credits**								16
	List of Elective Courses								
Elective I	Energy Engineering (CHE611)	Energy Conservation & Management (CHE 613)		Process Plant Simulation (CHE614)	Biochemical Engineering (CHE615)	Non-Conventional Energy Resources (CHE 612)			
Elective II	Process Design Decisions (CHE621)	Corrosion Engineering (CHE623)	Pulp & Paper Technology (CHE624)	Fertilizer Technology (CHE625)	Mathematical methods in chemical engineering (CHE622)				
Elective III	Advanced Heat Transfer (CHE711)	Energy Integration Analysis CHE712		Computer Aided Design in Chemical Engineering (CHE714)		Nanofluid Engineering (CHE716)	Petroleum Refinery & Petrochemicals (CHE715)		Process Intensification (CHE713)
Elective IV	Fluidization Engineering (CHE721)	Advanced Separation Processes (CHE722)	Sugar Technology (CHE723)	Pharmaceutical Engineering (CHE724)	Chemical vapor deposition (CHE725)	Scale-up and Pilot Plant Methods in Chemical Engineering (CHE726)			

Total Credits: 190

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

4 Year B. Tech Programme

(Branch: Chemical Engineering)

Batch 2014-18

SEMESTER-THIRD

Detailed Syllabus

&

Scheme of Examination

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE 301	Chemical Process Calculations	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test – II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical records/ MockInterviews/ others

Syllabus (Theory)

- Units and Dimensions, Conversion of units and conversion factors, Dimensional consistency and Mole unit, Density, specific gravity, mole fraction and mass fraction, Basis, Temperature and Pressure
- The chemical Equation and stoichiometry, The material balance, Program of Analysis of Material balance problems, Material balances without chemical reactions, Material balances with chemical reactions, Solving material balance problems involving multiple subsystems
- Recycle bypass and purge calculations, Ideal gas law calculations, ideal gas mixtures and partial pressure, Vapor pressure, saturation, Partial saturation and humidity
- The General energy balance, Calculation of enthalpy changes, Energy balances that account for chemical reactions
- Heats of solution and mixing, Humidity charts and their use, Analyzing the degrees of freedom in a steady-state process, solving material and energy balances using flow sheeting codes

Text Book

1. Himmelblau, D. M. “Basic principles & calculations in chemical Engg”, PHI, 6th ed., 1997.

Reference Book

1. Felder, R. M. & R. W. Rousseau, “Elementary Principles of Chemical Processes”, John Wiley & Sons, Inc., 3rd ed., 2000.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE 302	Fluid flow Operations	3	1	2	5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test – II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks**	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

1. Definition of a fluid, Basic equations, Dimensions and unit, Dimensionless equations and Consistent units, Dimensional equations, Method of analysis.
2. Concept of fluid continuum, Velocity and stress field, Viscosity, Viscosity of gases and liquids, Surface tension, Description and classification of fluid motions.
3. Basic equations of fluid statics, Pressure variation in static fluids, Hydrostatic Equilibrium in a centrifugal field, Buoyancy and stability.
4. Basic laws for a system, Conservation of mass and momentum equations for integral control volumes, Angular momentum principle [fixed control volume analysis only], First and second law of thermodynamics.
5. Conservation of mass and momentum equation [Navier-Stokes equations: Rectangular coordinates only], Motion of fluid elements.
6. Euler's equations, Bernoulli's equation, Relation between first law of thermodynamics and Bernoulli's equation
7. Buckingham PI theorem/ Reyleigh method, Significant dimensionless group in fluid mechanics (14, 15, 19 oct)
8. Flow between parallel plates, Flow in pipes of various cross-sections, Energy considerations of the flow, Pumps, Flow measurement techniques (venturi and orifice meters, pitot tubes etc.)
9. Boundary layer concept, Boundary layer thickness, Pressure gradient in boundary layer, Drag & flow through beds of solids
10. Agitated vessels and accessories, flow patters in vessels, velocity patterns and gradients, power consumption, blending & mixing, static mixers

Syllabus (Practical)

1. Bernoulli's theorem
2. Losses due to friction in pipe lines
3. Losses due to pipe fittings, sudden enlargement & contraction
4. Discharge through venturimeter, orificemeter & rotameter
5. Pitot tube
6. Darcy's law apparatus
7. Pressure drop through packed bed

8. Hydrodynamics of packed bed
9. Fluidized bed characteristics
10. Flow through helical coil
11. drag co-efficient apparatus
12. pressure drop in two phase flow

Text Books

1. Fox, R.W. and A.T. McDonalds, *Introduction to Fluid Mechanics (5th Ed.)*, John Wiley & Sons Inc., 2001. [ISBN: 9971-51-355-2]
2. McCabe, W.L., J.C. Smith and P. Harriott, *Unit Operations of Chemical Engineering (7th Ed.)*, McGraw Hill Inc., 2005. [ISBN 007-124710-6]

Reference Books

1. Bird, R.B., W.E. Stewart and E.N. Lightfoot, *Transport Phenomena (2nd Ed.)*, John Wiley and Sons Inc., 2002.
2. Welty, J.R., C.E. Wicks, R.E. Wilson, and G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer (4th Ed.), John Wiley and Sons Inc., 2001.
3. Coulson, J. M. and J. F. Richardson (with J. R. Backhurst and J. H. Harker), Coulson & Richardson's Chemical Engineering-Volume 1 (5th Ed.), Pergamon Press. Strength of Materials- A Rudimentary Apprach – M.A. Jayaram,
4. Bansal, R. K. A textbook of Fluid Mechanics and Hydraulic Machines

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE 303	Heat Transfer Operations	3	1	3	5.5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks**	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory):

1. Analogy with momentum transfer, Introduction to conductive, convective and radiative heat transfer
2. One dimensional steady state conduction for cartesian, radial and spherical coordinate system, with and without heat source, Fins and their function, Thermal contact resistance
3. Lumped heat capacity system, Transient heat flow in a semi-infinite solid, Convective boundary conditions
4. Viscous flow; Inviscid flow; Laminar and turbulent boundary layer; Boundary layer heat transfer
5. Empirical relations for pipe and tube flow; Flow across cylinders and spheres; Flow across tube banks; Liquid metal heat transfer
6. Theory and empirical relations for free convection from different geometric configurations such as plates, inclined surface, cylinder, sphere etc.; Combined free and forced convection
7. Mechanism and properties of radiation; Shape factor; Back body and gray body radiation; Gas radiation; Radiation shield; Radiation network (16,20,21,23)
8. Theory and empirical relations for film and dropwise condensation and boiling phenomena; Heat pipe (13-14oct)
9. Concept of overall heat transfer coefficient; LMTD method, effectiveness-NTU method, and Kern's method for heat exchanger design; Compact heat exchangers (27, 28, 3, 4, 6)
10. Types of evaporators; Evaporator capacity and economy; Single and multiple effect evaporators (17, 18 Nov)

Syllabus (Practical)

1. Friction in pipelines and fittings
2. Flow through packed beds
3. Flow through fluidized beds
4. Diffusion coefficient
5. Gas absorption
6. Helical coil heat exchanger
7. Shell and tube heat exchanger
8. Double pipe heat exchanger
9. Heat transfer in boiling kettle
10. Mass transfer with chemical reaction

Text book:

1. Holman, J.P., “Heat Transfer (9th Ed.)”, McGraw Hill, 2002.

Reference books:

1. McCabe, W.L., J.C. Smith, and P. Harriott, “Unit Operations of Chemical Engineering (6th Ed.)”, McGraw Hill, 2001.
2. Bird, R.B., W.E. Stewart, and E.N. Lightfoot, “Transport Phenomena”, John Wiley & Sons, 1994.
3. Welty, J.R., C.E. Wicks, R.E. Wilson, and G.L. Rorrer, “Fundamentals of Momentum, Heat and Mass Transfer (4th Ed.)”, John Wiley & Sons, 2001.
4. Binay, K. Dutta, “Heat Transfer- Principles and Applications (1st Ed.) ”, Prentice-Hall of India, 2001.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE304	Unit Processes in Organic Synthesis	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Atoms to molecules to materials for Engineers, Hybridization, sigma and pi bonds shape of the simple inorganic compounds, Molecular orbital theory and its application; Structure and stereo structure of molecules, Conformations, Newman, Sawhorse, Fischer, projections wedge and dash structural representation, equivalence of structural representations, Chirality, optical activity and isomerism, Dynamic stereochemistry, Geometrical isomerism in simple acyclic and cyclic molecules; Materials and their Characterization, Micro and macroscopic properties of molecules, Intermolecular forces, Molecular aggregation micelles;
- Reactions Dynamics, Chemical kinetics, Order and molecularity, zero, first and second order reactions, pseudo first order reaction , temperature dependence of reaction rates, Catalysis and some industrially important catalytic reactions; Stability and Reactivity of Molecules, Electron displacement effects – inductive, electromeric, resonance and hyper conjugation, Reactive sites in molecules - functional groups. Reaction Mechanism, Fission of a covalent Bond, types of reactions – nucleophilic (SN1 & SN2, SNi, SNAr) and electrophilic substitution reactions (Nitration, Sulphonation, Halogenation, and Friedel Crafts reaction) and their mechanism , regio and Stereochemistry of involved reactions
- Purification, Physical (crystallization, fractional crystallization , distillation , fractional distillation, steam distillation) and chemical methods of purification; General chromatographic (Adsorption and partition) techniques(column thin layer and paper chromatography) and their application; Criteria of purity, Melting and Boiling point, chromatography , particle size measurement and surface area Characterization, Surface tension, Viscosity ,Conductivity , and Absorption Spectroscopy (IR, UV – Visible , NMR);
- Water and its treatment , Alkalinity of water, estimation of alkalinity, Hard and soft water, hardness- units, determination of hardness by complexometric Titration, Removal of hardness of water- Zeolite , ion exchange process, Boiler Feed water, descaling of boilers desalination of brackish water, Reverse osmosis, potable water;
- Polymers and Polymerization (ionic, anionic and free radical induced), Properties of polymers , Number average and Weight average molecular weighs, characterization of polymer samples , polymer blends, Stereo structures of polymers, Dendrimers, Some examples of common polymers used in Industry, Natural and Synthetic rubber, Silicones, Composites, Adhesives, Conducting polymers, Biodegradable polymers; Metallic corrosion and its prevention, electrolysis , Industrial electrolytic processes-(aluminium). Fuel cells and batteries.

Text/References Books:

1. Organic Chemistry, P.Y. Bruice , Ninth Impression, 2011, Pearson India
2. Chemistry 3 , A. Burrows, john Holman, A, Parsons, G. Pilling, G.Price, Oxford University Press, 2009
3. Engineering Chemistry, A Text book of Chemistry for Engineers published by John Wiley and Sons,India 2011
4. Unit processes in Organic Synthesis by Groggins, Tata McGraw Hill, 2001
5. Spectroscopic Methods in Organic Chemistry, D H Williams and I. Fleming, Tata McGraw Hill, 1991
6. Engineering Chemistry, R. Mukhopadhyay, S. Datta, New age international publishers, 2007

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
MA 301	Engineering Mathematics – III	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

Integral Transforms

Laplace transform and its properties, Fourier Transform, Discrete Fourier transform, Fast Fourier Transform

Applications of Transform Calculus

Integral transform method for solving differential equations, Systems of Linear Differential Equations

Special Functions

Legendre and Bessel functions, series representations and recurrence relations

Calculus of variations

Extremal function, Euler Equation, Isoperimetric problems

Complex Analysis

Functions of complex variables and its derivatives, Integration in complex planes, Series, Singularities and Residues, Evaluation of Real Integrals, Conformal mappings, Schwarz-Christoffel Transformations

Text books and Reference books

1. Dennis G. Zill and Warren S. Wright, Advanced Engineering Mathematics, Fourth Edition (Student Edition), Jones & Barlett, Viba, New Delhi, 2011
2. Peter V. O'Neil, Advanced Engineering Mathematics, Seventh Indian Reprint, Cengage Learning, New Delhi, 2011.
3. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley 9th Edition.
4. B. S. Grewal, Higher Engineering Mathematics, 41st Ed., Khanna Publishers, Delhi, 2011.
5. B. V. Ramana, Higher Engineering Mathematics, Tata Mcgraw Hill.
6. Potter M.C., Goldberg J.L., Edward F.A., Advanced Engineering Mathematics, 3rd Edition, Oxford University Press, 2005

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
HS302	Principles of Management for Engineers	2	0	0	2

Evaluation Scheme (Theory)					Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation/ Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	50	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Course Syllabi (Theory):

- **Concepts of management:** Functions and Responsibilities of managers, Principles of management and visiting various, Schools of management Thoughts in developing, Excellent managers
- **Planning:** Nature and purpose of planning, Planning process and principles, Types of planning, Advantages and disadvantages of planning, Concept of objectives and types of objectives, Case analysis
- **Organizing:** Nature and purpose of organizing, Process of organizing, Span of management and determination of span of management, Principles of organizing, Departmentalization, delegation and, Decentralization. Case analysis
- **Directing and leading:** Requirements of Effective directions, Giving orders, motivation, Nature of leadership, leadership and management, Recapitulation and case discussion
- **Controlling:** concept and process, Need for controlling and types of control methods, Essentials of effective control, Benefits and problems in control systems. Case analysis
- Social responsibilities of business: Meaning, Social responsibility of business towards different groups, Social performance of business in India, Social audit, Business ethics and corporate governance

Text Books:

1. Tripathy, P.C. and Reddy, P. N. "Principles of Management". . McGraw Hill, New Delhi.4th ed. 2008.

Reference Books:

1. Koontz, Herold and Weihrich, Heinz. "Management". McGraw Hill, New York. 9th ed. 1988.
2. Stoner, James A. F. and Freeman, R Edward. "Management". Prentice Hall of India, New Delhi. 6th e, 1989.
3. Bateman, T. S. and Snell, S. A. "Management: Leading and Collaborating in a Competitive World", McGraw Hill Irwin. 8th edition,2009.
4. Draft, R. L. "Principles of Management". Cengage learning.2009
5. Schermerhron, J. R. "Introduction to Management", 10th edition, Wiley India. 2009

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CSE 302	Object Oriented Programming	3	0	4	5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Course Syllabi (Theory):

Identifiers and constants (Literals), Keywords, Data Types, The Operators, New Casting Operators, Typeid and throw, The Conditional structures and Looping Constructs

Difference between Struct and class in C++, The difference between Union and Class, Static Data members of a class, Pointer to objects and pointer to members of class, The local classes,

Assigning Objects

Introduction to Functions, The Inline function, Default Arguments to the function, Functions with object as parameters, Call by reference and return by reference, Prototyping and Overloading, Friend functions, Const and Volatile functions, Static functions, Private and Public functions

Introduction to constructors, The explicit constructors, Parameterized constructors, Multiple constructors, Constructors with default arguments, Dynamic Initialization, Constructor with dynamic allocation, copy constructors, The member initialization list, destructors

Overloading Operators, The need, Defining derived class using single base class, Derivation using public, private and protected access modifiers

The implementation of Inheritance in the C++ object model, multiple-inheritance, Abstract classes, Composite objects (container objects), Compile Time and Runtime Polymorphism

Introduction, Need for Exception handling, Components of exception handling mechanism

Course Syllabi (Practical):

Programs using C++/Java which covers following concepts:

- Declaration and Usage of Classes and Objects
- Constructors and Destructors.
- Overloaded Functions and Overloaded Operators.
- Inheritance
- Exception handling mechanism.

Text Books:

1. Object Oriented Programming using C++ and Java, E. Balagurusamy, Tata McGraw Hill.

Reference Books:

1. Programming with ANSI C++ by Bhushan Trivedi, Oxford University Press
2. An Introduction to Object Oriented Programming with Java, C Thomas WU, Fourth Edition, Tata McGraw Hill.

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

4 Year B. Tech Programme

(Branch: Chemical Engineering)

Batch 2014-18

SEMESTER-FOURTH

Detailed Syllabus

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Scheme of Examination

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE404	Chemical Reaction Engineering - I	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

Introduction: Definition of reaction rates, variable affecting reaction rates, classification of reactions, order, molecularity.

Kinetics of Homogenous Reactions: Concentration dependent term of a rate equation, temperature dependent term of a rate equation, searching for a mechanism.

Interpretation of Batch Reactor Data: Constant volume batch reactor, variable volume batch reactor, temperature and reaction rate.

Introduction to Reactor Design: Ideal reactors for single reaction: Ideal batch reactor, steady state mixed flow Reactor, steady state PFR, Holding time and space time for flow systems.

Design for single reactions: Size comparison, multiple reactor systems, recycle reactor, auto catalytic reactions.

Design for multiple reactions: Reactions in parallel, reactions in series, series –parallel reactions.

Temperature and Pressure Effects on Reactions: Single reactions: Heat of reaction, equilibrium constants, graphical design procedure, optimum temperature progression, adiabatic operations. Multiple reactions: Product distribution and temperature.

Stability of Multiple Steady –States: Multiple steady-states of a CSTR with a first order reaction, Ignition –extinction curve.

Text/Reference Books:

1. Levenspiel, O., "Chemical Reaction Engineering" 3rd ed., John Wiley & Sons, Singapore 1999.
2. Fogler, H.S., "Elements of Chemical Reaction Engineering" 3rd ed., Prentice Hall of India, 2003.
3. Smith, J.M. "Chemical Engineering Kinetics", 3rded., McGraw-Hill, 1981.
4. Dawande S.D. "Principles of Chemical Reaction Engineering," 2nd ed., Central Techno Publications, Nagpur, 2003.
5. Richardson, J.F. and peacock D.G., "Coulson and Richardson's Chemical Engineering,"Vol.3, 3rd ed. Asian Books Pvt. Ltd. New Delhi 1998.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE402	Mass Transfer Operations	3	1	3	5.5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks**	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

- Unit operations and unit process, Basic concepts: phase, equilibrium, property, system, driving force, chemical potential. Classification of mass transfer operations.
- Molecular diffusion and fluxes, Molecular diffusion in Gases (stagnant film, equimolal counter diffusion), Diffusivity of gases and liquids.
- Relations between mass transfer coefficients, Reynolds analogy. Equilibrium, diffusion between phases, material balances, stages.
- Equilibrium solubility of gases in liquids, one component transfer: material balance for counter - and co-current processes, multi stage operations, non-isothermal operations, calculation of height of packed absorber/desorber, multi-component systems, absorption with chemical reaction.
- Vapor-liquid equilibrium, flash vaporization, differential distillation, Continuous distillation, multistage columns, overall mass and enthalpy balances, McCabe-Thiele method, Ponchon-Savarit method, use of open steam, multiple feed, side streams, azeotropic and extractive distillations.
- Liquid-liquid equilibrium, distribution curves, triangular and solvent free coordinates, systems of three liquids-one pair partially soluble, insoluble liquids, effect of temperature, continuous counter-current multi-stage extraction, and continuous counter-current extraction with reflux.
- Solid-liquid extraction, underflow and overflow locus, Multistage cross current extraction, Calculation of no. of stages for cross current flow.

Syllabus (Practical)

1. LIQUID-LIQUID EXTRACTION IN A PACKED TOWER
2. YORK SCHEIBEL'S EXTRACTION UNIT
3. SOLID-LIQUID EXTRACTION (BONNOTTO TYPE)
4. SIEVE PLATE DISTILLATION COLUMN
5. SIMPLE BATCH DISTILLATION SETUP
6. ABSORPTION IN WETTED WALL COLUMN

7. VAPOUR IN AIR DIFFUSION APPARATUS
8. FLUIDIZED BED DRYER
9. BATCH CRYSTALLIZER
10. VAPOUR-LIQUID EQUILIBRIUM SET-UP
11. MASS TRANSFER WITH & WITHOUT CHEMICAL REACTION (SOLID- LIQUID)
12. ADSORPTION IN PACKED BED

Text Books:

1. Treybal, R.E., "Mass Transfer Operations," 3rd Ed. (International Edition), McGraw-Hill Book Company, Singapore, 1980.
2. McCabe, W. L., Smith, J. C., Harriott, P., "Unit Operations of Chemical Engineering," 7th Ed. (International Edition), McGraw-Hill Education (Asia), Singapore, 2005.

Reference Books:

1. Foust, A. S., Wenzel, L. A., Clump, C. W., Anderson, L. B., "Principles of Unit Operations," 2nd Ed., John Wiley and Sons, New York, 1980.
2. Perry, R. H., Green, D. W., "Perry's Chemical Engineers' Hand Book," 7th Ed., McGraw-Hill, New York, 2001.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE403	Chemical Engineering Thermodynamics	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

- Scope and Objectives of course, methodology, First law, Closed System, State and State functions
- Equilibrium, Phase rule, Reversible Process, Const-V and Const-P Processes,Enthalpy, heat capacity, First law for Open systems, PVT behaviour of pure substances, Virial Equations, Ideal gas
- Applications of Virial Equations, Cubic Equations of State, Generalized correlations for gases and liquids, Sensible heat effects, Latent heat, Standard heats of reaction, formation, combustion
- Temperature dependence of $\Delta H°$, heat effects of industrial reactions, Statements of second law, Heat engines, Thermodynamic temperature Scale, Entropy, ΔS for an ideal gas, Entropy balance for Open Systems, Ideal work, Lost work, Third law, Property relations for homogeneous phases.
- Residual properties and their calculations by cubic equations, Two-phase systems, thermodynamic diagrams and tables
- Generalized property correlations for gases, Duct flow of compressible fluids, Expansion Processes, Compression Processes, Carnot refrigerator, Vapour-compression cycle, Choice of refrigerant, Absorption refrigeration, Heat pump, Liquefaction Processes
- Nature of Equilibrium, Phase rule, Duhem's theorem, VLE; Qualitative behavior, Simple models for VLE, VLE by Modified Raoult's law, K-value correlations, Fundamental Property Relation, Chemical potential and Phase equilibrium, Partial Properties, Ideal gas mixtures, Fugacities of pure species
- Fugacities of Species in solution, Generalized Correlations, Ideal Solution, Excess Properties,
- Liquid-phase properties from VLE data, Models for Excess Gibbs energy, Property changes of Mixing, Heat effects of Mixing processes, Reaction coordinate, Equilibrium criteria for chemical reactions, Equilibrium constants and their variation with temperature
- Evaluation of Equilibrium constants, Relation of Equilibrium Constants with Compositions, Equilibrium conversions for Single Reactions, Phase Rule and Duhem's theorem for Reacting Systems, Multireaction Equilibria

Text Book:

1. J.M.Smith, and Others,"Intro to Chemical Engineering Thermodynamics", MGHFSE, 6th ed., 2001.

Reference Books:

2. YVC Rao, "Chemical Engineering Thermodynamics", Universities Press,1997.
3. KV Narayanan, "A Textbook of Chemical Engineering Thermodynamics". Prentice Hall of India, 2001.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE405	Mechanical Operations	3	1	3	5.5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

- Characterization of Solid particles, properties of masses of particles, Storage and conveying of solids, mixing of solids, Mixers, Size reduction, equipment for size reduction
- Screening, screening equipment, Filtration equipment, Filtration calculations, Membrane filtration, gravity settling processes, Centrifugal sedimentation processes
- Principles of drying, Cross circulation drying, Through circulation drying, dryers, Adsorption, Ion Exchange
- Chromatography, Separation of gases , Separation of liquids, Introduction, crystal geometry, equilibria, super saturation,
- Nucleation, Crystal growth, equipment , Crystallizer design

Syllabus (Practical)

1. Crushing, grinding, screening
2. Vacuum filtration
3. Plate and frame filtration
4. Rotary drum filtration
5. Froth flotation
6. Sedimentation and thickening
7. Centrifugal double cone classifier
8. Drying
9. Centrifugal pump characteristics
10. Reciprocating pump characteristics

Text Books:

1. McCabe W. L., and Smith J. M., &Harriott P., *Unit Operations of Chemical Engineering*, 7th Ed., McGraw-Hill International Edition, 2006.

Reference Books:

1. Chemical Engineering (Volumes 1-6), Coulson J. M., Richardson J. F. & others, Pergamon Press, London, 1978 & 1997.
2. Principles of Unit Operations, Foust A. N. & others, 2nd Edition, John Wiley & Sons, 1980.
3. Unit Operations, Brown G. G. & others, Chapman & Hall, 1950.
4. Chemical Engineers Handbook, Perry, R. H. (Ed.), McGraw-Hill, New York (all editions).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
MA 402	Numerical & Statistical Methods	3	0	2	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

- **Modeling, Computers, and Error Analysis**: Mathematical Modeling and solution using Programming and Software, Computer Arithmetic and Errors: Approximations and Round-Off Errors, Truncation Errors and the Taylor Series
- **Transcendental and polynomial equation**: Solution of non-linear Equations: Bracketing Methods, Open Methods, Roots of Polynomials
- **Linear Algebraic Equations**: LU Decomposition and Matrix Inversion, Iterative methods for solving system of linear equations.
- **Interpolation and approximation**: Interpolation for equally and unequally spaced points, Lagrangian Polynomial, Curve Fitting: Least-Squares Regression
- **Numerical Differentiation and Integration**: Numerical Differentiation and Integration, Newton-Cotes Integration Formulae.
- **Ordinary Differential Equations**: Single step methods for solving first order ordinary differential equation
- **Random Variables and probability distributions**: Introduction to probability, Discrete and continuous random variables, probability mass, probability density and cumulative distribution functions, Mathematical expectation, Chebyshev's inequality, Discrete and continuous probability distributions
- **Sampling distributions**: Sampling, Types of sampling, sampling errors, sampling distribution of means, variance and proportions for normal population, The Central Limit Theorem, Chi-Square, t and F distributions
- **Estimation**: Estimators, Point and interval estimation, confidence intervals for parameters in one sample and two sample problems of normal populations, confidence intervals for proportions
- **Testing of Hypotheses**: Null and alternative hypotheses, the critical and acceptance regions, two types of error, Parametric and Non-parametric tests, Chi-square goodness of fit test, Contingency tables.
- **Correlation and regression**: Types of Relationships, Scatter Diagrams, Regression Line, Coefficients of Determination and Correlation
- **Analysis of variance**: One way analysis of variance, experimental design, two way analysis of variance without interaction

Syllabus (Practical)

1. Numerical solution of algebraic and transcendental equations.
2. Numerical solution of system of linear equations.
3. Interpolation.
4. Numerical differentiation.
5. Numerical integration.
6. Numerical solution of differential equations.
7. Data Analysis using Correlation and Regression
8. Test of Hypothesis
9. Analysis of Variance

Text books and Reference books

1. K. E. Atkinson, Introduction to Numerical Analysis, John Wiley and Sons.
2. M.K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical Methods For Scientific And Engineering Computation, New age International publishers, New Delhi.
3. Steven C Chapra, Raymond P Canale, Numerical Methods for Engineers, 6/e, Mc Graw Hill
4. Srimanta Pal, Numerical Methods: Principles, Analyses and Algorithms, Oxford University Press, New Delhi.
5. Cheney and Kincaid, Numerical Methods and Applications, Cengage Publications, New Delhi.
6. Cleve B. Moler, Numerical Computing with MATLAB, Prentice Hall of India, New Delhi .
7. Rishard A. Johnson, Miller and Freund's probability and Statistics for Engineers, PHI, 8th Ed.
8. Ravichandran J., Probaility and statistics for Engineers, Wiley India, New Delhi.
9. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, Inc., 3rd Edition (2004).
10. Prem S. Mann, Introductory Statistics, Wiley publication, 7th edition.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE406	Fuel and Combustion Technology	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

- **Introduction**: Introduction and History of Fuels (Solid, Liquid and Gaseous fuels), Production, present scenario and consumption pattern of fuels, Fundamental definitions, properties of fuels and various measurement techniques
- **Solid Fossil Fuels (Coal):** Coal classification, composition and basis, Coal mining, Coal preparation and washing, Combustion of coal and coke making (Action of heat on different coal samples, Different types of coal combustion techniques, Coal tar distillation), Coal liquefaction (Direct and Indirect Liquefaction), Coal gasification
- **Liquid Fossil Fuels (Petroleum):** Exploration of crude petroleum, Evaluation of crude, Distillation (Atmospheric distillation, Vacuum distillation), Secondary processing, Cracking (Thermal cracking, Visbreaking, Coking, Catalytic cracking), Reforming of naphtha, Hydrotreatment, dewaxing, deasphalting, Refinery equipments
- **Gaseous Fuels:** Natural gas and LPG, Refinery gases, Producer gas, Water gas, Hydrogen, Acetylene and Other fuel gases.
- **Combustion Technology:** Fundamentals of thermochemistry, Combustion air calculation, Calculation of calorific value of fuels, Adiabatic flame temperature calculation, Mechanism and kinetics of combustion, Flame properties, Combustion burners, Combustion furnaces, Internal combustion engines

Text/Reference Books

- Modern Petroleum Technology, Vol 1, Upstream, Ed. by Richard A. Dave, IP, 6th ed., John Wiley & Sons. Ltd.
- Modern Petroleum Technology, Vol 2, Downstream, Ed. by Alan G. Lucas, IP, 6th ed., John Wiley & Sons. Ltd.
- Combustion, Irvin Glassman, 2nd ed., Academic Press.
- Modern Petroleum Refining Processes, B.K. Bhaskar Rao, 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd.
- Report on the project "Coal Combustion Study", sponsored by Tata Tron and Steel Company Ltd., Jamshedpur.
- Fuels Combustion and Furnaces, John Griswold, Mc-Graw Hill Book Company Inc.
- Fuels and Combustion, Samir Sarkar, 3rd. ed Universities Press.
- Petroleum Refinery Engineering, W.L. Nelson, 4th ed. Mc-Graw Hill Book Company.

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

4 Year B. Tech Programme

(Branch: Chemical Engineering)

Batch 2014-18

SEMESTER-FIFTH

Detailed Syllabus

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Scheme of Examination

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE501	Chemical Reaction Engineering - II	3	1	3	5.5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

Catalysts: Description, method of preparation and manufacture; catalyst characterization –BET surface area, pore volume, pore size distribution.

Catalyst Reaction Kinetic Models: Physical and chemical absorption; determination of rate expressions using absorption, surface reaction and desorption as rate-controlling steps.

Determination of Global Rate of Reaction: Heterogeneous laboratory reactors; Determination of rate expressions from experimental data.

Effect of Intrapellet Diffusion on Reaction Rates in Isothermal Pellets: Concept of effectiveness factor, Thiele modulus,experimental determination of effectiveness factor-wesiz-Prater criteria, Non-Isothermal effectiveness factor; Prater number, maximum temperature rise in a pellet, multiple steady states in heterogeneous reactors.

Non-catalytic Gas-Solid Reactions: Progressive conversion model, Shrinking core model; various controlling regimes, design of gas-solid reactors.

Gas-Liquid Reactions: Effect of diffusion on rate of reaction, enhancement factor.
Introduction to Design of Heterogeneous Reactors: One dimensional model for fixed-bed reactors, parametric sensitivity; design of fluidized bed reactors

Syllabus (Practical)

1. Isothermal CSTR
2. Cascade CSTR
3. Plug flow reactor (straight tube type)
4. Isothermal plug flow reactor (coiled tube type)
5. Isothermal batch reactor
6. Isothermal semi-batch reactor
7. Packed bed reactor
8. Combined flow reactor
9. Liquid phase chemical reactor

10. RTD studies in CSTR
11. RTD studies in plug flow reactor (coiled tube type)
12. RTD of packed bed reactor
13. Hydrodynamics of trickle bed reactor
14. Condensation polymerisation set-up
15. Spinning basket reactor

Text/Reference Books:

1. Levenspiel, O., "Chemical Reaction Engineering"3rdEd., John Wiley, 1999.
2. Smith, J.M., "Chemical Engineering Kinetics"3rdEd., Mc Graw-Hill, 1981.
3. Fogler, H.S., "Elements of Chemical Reaction Engineering"3rdEd., Prentice-Hall of India, Delhi, 2003.
4. Carberry, J.J., "Catalytic Reaction Engineering"Mc Graw-Hill, 1976.
5. Dawande, S.D., "Principles of Reaction Engineering"Central Techno Pub.,Nagpur, 2001.
6. Levenspiel, O., "The Chemical Reactor Omnibook"OSU Bookstores, Corvallis Oregon, 1996.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE502	Process Dynamics & Control	3	1	2	5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

- Need of process control, process control strategies, process control activities, Modeling principles, dynamic models, degrees of freedom analysis, solution of dynamic models, Solution of differential equation, Development and properties of transfer functions, linearization of non-linear models, state-space and transfer function matrix models
- Response of first and second order processes, Dynamic response of higher order systems, Model development using non-linear regression, fitting first and second order models, neural network model, discrete time models, identification of systems, Concept & type of feedback control, block diagram representation, response of it, PID controller
- Transducers, transmitters, final control elements, Influence of process design on process control, degrees of freedom for process control, Selection of variables, Closed loop representation, transfer functions, stability analysis, Performance criterion, Model based design, controller tuning relations, Bode, Nyquist, Gain and Phase margin, closed-loop frequency response and sensitivity functions
- Ratio control, feed forward controller design based on steady state and dynamics equation, feedforward-feed-back controller, Cascade control, time-delay compensation, inferential control, adaptive control, Predictions for SISO and MIMO problems, MPC calculations, Set-point calculations, design and tuning parameters, Signal processing, data filtering, tuning of digital PID controllers, minimum variance control

Syllabus (Practical)

1. PRESSURE CONTROL TRAINER
2. LEVEL CONTROL TRAINER
3. TEMPERATURE CONTROL TRAINER
4. FLOW CONTROL TRAINER
5. CONTROL VALVE CHARACTERISTICS (Linear, Equal Percent & Quick Opening)
6. CHARACTERISTICS OF PID CONTROLLER
7. STUDY OF I/P AND P/I WITH MINI COMPRESSOR
8. CASCADE CONTROL TRAINER: LEVEL + FLOW (SCADA) WITH MINI COMPRESSOR AND SCADA SOFTWARE

9. MULTIPROCESS TRAINER: LEVEL, FLOW, CASCADE, RATIO &FEEDFORWARD (SCADA)
10. FIRST-ORDER AND SECOND-ORDER SYSTEM
11. PLC TRAINER
12. FLAPPER - NOZZLE SYSTEMWITH MINI COMPRESSOR
13. MULTI VARIABLE CONTROL TRAINER
14. INTERACTING & NON - INTERACTING SYSTEM
15. DCS TRAINER (HYBRID CONTROLLER)

Text Book:

- Seborg, D. E., Edgar, T. F. and Mellichamp, D.A., "Process Dynamics and Control", 2nd Ed., John Wiley and Sons, 2004

Reference Books:

- Coughanowr, D.R., Process Systems Analysis and Control, 2nd Ed., McGraw-Hill, 1991.
- George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice Hall, 1984.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE503	Process Modelling and Simulation	3	1	2	5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

Introduction: Use and scope of mathematical modeling, Principles of model formulation, Role and importance of steady-state and dynamic simulation, Classification of models, Model building, Modeling difficulties, Degree-of-freedom analysis, Selection of design variables, Types of equations.

Fundamental Laws: Equations of continuity, energy, momentum, transport, and state, Transport properties, Equilibrium and chemical kinetics, Review of thermodynamic correlations for the estimation of physical properties like phase equilibria, bubble and dew points etc, Prediction of enthalpy departure and VLE characteristics from equation of state by the application of numerical methods.

Modeling of Specific Systems: Constant and variable holdup CSTRs under isothermal and non-isothermal conditions, Stability analysis, Gas phase pressurized CSTR, Two phase CSTR, Non-isothermal PFR, Batch and semi-batch reactors, Heat conduction in a bar, Laminar flow of Newtonian liquid in a pipe, Gravity flow tank, Single component vaporizer, Multi-component flash drum, Absorption column, Ideal binary distillation column and non-ideal multi-component distillation column, Batch distillation with holdup etc.

Simulation: Simulation of the models, Sequential modular approach, Equation oriented approach, Partitioning and tearing, Introduction and use of process simulation software (ASPEN/Hysis) for flow sheet simulation.

Text Books:

1. Luyben W.L., Process Modeling, Simulation, and Control for Chemical Engineering, McGraw-Hill (1998).

Reference Books:

1. Denn, M. M., Process Modeling, Longman Sc & Tech. (1987).
2. Himmelblau, D.M and Bischoff, K.B., Process Analysis and Simulation: Deterministic Systems, John Wiley (1968).
3. Holland, C. D., Fundamentals and Modeling of Separation Processes: Absorption, Distillation, Evaporation and Extraction, Englewood Cliffs, Prentice-Hall (1974).
4. Babu, B.V., Process Plant Simulation, Oxford University Press (2004).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE504	Separation Processes	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

Liquid-Liquid extraction, Ternary liquid-liquid systems, Equipment, General design considerations, Hunter-Nash graphical equilibrium-stage method; Leaching and washing, Equilibrium-stage model for leaching and washing, Rate-based model for leaching, Equipment for leaching; humidification and water cooling, Drying of wet solids, Principles of drying, Cross circulation drying, Through circulation drying, dryers; adsorption, ion exchange; crystallization, crystal geometry, equilibrium, super saturation, Nucleation Crystal growth, equipment Crystallizer design

Text Book:

1. Seader, J.D., Henley, E.J., “Separation Process Principles,” 2nd Edition, Wiley India Pvt. Ltd., NewDelhi, 2006.

Reference Books:

1. Treybal, R.E., “Mass Transfer Operations,” 3rd Ed. (International Edition), McGraw-Hill BookCompany, Singapore, 1980.
2. Dutta, B. K., “Principles of Mass Transfer and Separation Processes,” Prentice-Hall of India Pvt.Ltd., New Delhi, 2007.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE506	Process Instrumentation	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

Introduction, general principles of measurement, its classification by physical characteristics, direct and inferential measurement.

Static and dynamic characteristics of instruments. Measurement of temperature, pH, pressure, vacuum, flow rate, liquid level, differential pressure

Viscosity, conductivity, nuclear radiation, humidity and gas composition, spectroscopy.

Classification of sensors and transducers. Building blocks of an instrument, transducer, amplifier signal conditioner, signal isolation, transmission, display, data acquisition modules, interfaces, recording.

Control centre, instrumentation diagram, On line instrumentation in modern plants.

Text/Reference Books:

1. Nakra, “Instrumentation, Measurement and Analysis”; Tata McGraw Hill, New Delhi.
2. Patranabis, D., “Principles of Industrial Instrumentation”2nded. Tata McGraw Hill, New Delhi.
3. Eckman, D.P., “Industrial Instrumentation”, Wiley Eastern, 1978.
4. Liptak, B.G., “Industrial Engineers’Handbook”Vol.1 and 2, CRC Press, 1994.
5. Andrew, W.G., et al., “Applied Instrumentation in the Process Industries,”Gulf Pub.1993.
6. Wightman, E.J., “Instrumentation in Process Control,”Butterworth, 1972.
7. Doebelin, E., “Measurement Systems: Applications and Design,”4thed., McGraw Hill, 1990

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE505	Chemical Engineering Materials	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

- Introduction, Unit cell, Crystallographic directions and planes, Linear and planner densities, close-packed crystal structures, Crystal structures of ceramics
- Determination of crystal structure, Bragg's Law, diffraction technique, Vacancies and interstitials, dislocations and grain boundaries, Optical and electron microscopy, grain size determination
- Steady and non-steady diffusion, Stress-strain, elastic and plastic deformations, Slip systems, plastic deformation, strengthening mechanisms
- Phases, microstructures, phase equilibria, Fe-Fe3C phase diagram, development of microstructure in Fe-C alloys, Avrami rate equations, Isothermal transformation diagrams, continuous cooling transformations, Mechanical behavior of Fe-C alloys, tempered martensite, Molecular weight, molecular configurations of polymers,
- Mechanisms of deformation and strengthening in polymers, glass transitions

Text Book:

1. Materials Science and Engineering-An introduction by W.D. Callister, 7th edition, John Wiley (2007) ISBN 10: 81-265-1076-5 or ISBN 13: 978-81-265-1076-4.

Reference Books:

1. Materials science and engineering by V. Raghavan, 4th edition, Prentice Hall of India, ISBN 10: 81-203-1261-9
2. Materials science and engineering by Smith, Hashemi, and Prakash, 4th edition (2008), Tata McGraw Hill education pvt. Limited, ISBN 10: 0-07-066717-9 or ISBN 13: 978-0-07-066717-4.
3. Materials science and engineering by Askeland and Fulay, Cengage Learning, ISBN 10: 81-315-1255-X or ISBN 13: 978-81-315-1255-5.
4. Essentials to Materials Science and Engineering by Askeland and Phule, Thomson learning, Indian reprint 2007, ISBN 10: 81-315-0233-3.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
PS501	Practice School – I				4

Evaluation Scheme

S. No.	Evaluation Component	Marks (100) (Weightage %)
1	Quiz-I	4
2	Quiz-II	4
3	Group Discussion-I	4
4	Group Discussion-II	4
5	Seminar-I	4
6	Seminar-II	4
7	Diary-I	4
8	Diary-II	4
9	Observation-I	4
10	Observation- II	4
11	Mid Term Evaluation (Project Report and Presentation/Viva)	20
12	Final Evaluation (Project Report and Presentation/Viva)	40

Course Syllabi:

This course is for 6 weeks at the end of 4th semester during summer term of 4 year full time B. Tech. and 5 year Integrated Dual degree (B.Tech + M.Tech, B.Tech + MBA) programs in all the engineering disciplines. The objective of this programme is to provide the students an understanding of working of corporate world in various functions associated with an Industry/Organization. During this programme, they will observe and learn various real world applications of their curricula and develop an understanding of vast engineering operations and its various facets such as inventory, productivity, management, information systems, human resource development, data analysis etc. The general nature of PS-1 assignments is of study and orientation.

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

4 Year B. Tech Programme

(Branch: Chemical Engineering)

Batch 2014-18

SEMESTER-SIXTH

Detailed Syllabus

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Scheme of Examination

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE602	Chemical Process Technology	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Chemical Industries – Facts and figures, Unit operations and Unit Process concepts, General Principles applied in studying an Industry, Unit operations and Unit Process concepts, General Principles applied in studying an Industry
- Project formulation, its evaluation and implementation, Chamber Process, Contact Process, DCDA Process, Ammonia Oxidation Processes: Mono Pressure and Mixed Pressure Processes, Urea Production Processes; Ammonium Nitrate Production Processes;
- Phosphate and Potash based fertilizers production processes; Phosphoric acid manufacturing processes, Kraft Process, sulfite Process, Mechanical Pulping; Paper making, Production of lignin chemicals
- Dry and wet cement manufacturing processes, Mechanical and solvent based extraction processes, Hydrogenation of oils; isomerization, interesterification, Soap manufacturing processes, glycerin recovery process, alfol process of detergent production
- Coal combustion, carbonization and liquefaction technologies, Origin and classification of petroleum, atmospheric and vacuum distillation processes; Reforming, Solvent deasphalting, solvent dewaxing, Chemicals from C_1 compounds, Chemicals from C_2 compounds, Chemicals from C_3 compounds, Chemicals from C_4 compounds, Various polymerization processes

Text Book:

1. "Dryden's Outlines of Chemical Technology for the 21st Century" Edited by M. GopalaRao and Marshall Sittig. East West Press, 3rd Ed., 1997.

Reference Books:

1. George T. Austin, Shreve's Chemical Process Industries by, McGraw Hill, 5th Edn., 1984.
2. D. Sen, Reference book on Chemical Engineering, Vol- I", New Age International Publishers, 2005

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE603	Process Equipment Design	3	1	3	5.5

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks**
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

**The ratio of weightage between Theory and Practical content will be 60%: 40%

Syllabus (Theory)

- Introduction, Considerations in process equipment design, Materials of construction, Mechanical Properties, Materials, Corrosion, Protective Coatings, Choice of Materials, Criteria in vessel design, Design of shells for flat bottomed cylindrical vessels.
- Shell design of large storage tanks, Design of bottoms and roofs for flat bottomed cylindrical vessel, Proportioning and Head Selection for cylindrical vessels with formed closures, Stress Considerations in the selection of Flat plate and conical closures, Design of pressure vessels
- Design of high pressure vessels, Design of shell & tube heat exchanger, Process Design, Design of shell & tube heat exchanger, Mechanical Design, Design of Distillation and Absorption column, Column sizing approximation, Plate Contactors, Plate Hydraulic Design, Design of Distillation and Absorption column
- Stresses in column shell, Design and construction features of column internals, Design of reaction vessels, Design considerations of heating systems, Design of agitator system components
- Shaft, agitator, couplings, bearings, stabilizers, seals, Design of supports for vessels, Skirt supports, saddle supports, Design of Flanges, Process Hazards and safety measures in equipment design

Syllabus (Practical)

1. Mechanical design of storage vessel including roof design
2. Mechanical design of high pressure vessel
3. Mechanical design of reaction vessel carrying out exothermic reaction
4. Mechanical design of distillation column
5. Mechanical design of heat exchanger unit
6. Hydraulic design of distillation column
7. Hydraulic design of absorption column
8. Mechanical design of agitated vessel
9. Mechanical design of chimney

Text Book:

1. **"**Process Equipment Design"- Lloyd E. Brownell, Edwin H. Young, John Wiley & Sons Publications, 2004.
2. "Process Equipment Design"- M V Joshi, V VMahajani, Macmillan India Limited, New Delhi.

Reference Book

1. Coulsonos and Richardson's Chemical Engineering, Volume 6, Sinnott, R.K., Asian Books Pvt. Ltd, 1998

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE604	Transport Phenomena	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Scope and objectives of course, methodology, Newton's law of viscosity, molecular theories of viscosity, Convective momentum transport, Shell momentum balances, boundary conditions, Examples, Equations of continuity, motion and mechanical energy, Examples
- Dimensional analysis, Time-dependent flow of Newtonian fluids, Solving flow problems using stream functions and velocity potential, Boundary layer theory, Fourier's law of heat conduction, molecular theories of thermal conductivity, Convective transport of energy, work associated with molecular motions, Shell energy balances, examples, Forced and free convection, Various forms of energy equations, Examples
- Dimensional analysis, Unsteady state heat conduction in solids and in laminar flow, Boundary layer theory for non-isothermal flow, Fick's law of binary diffusion, molecular theories of diffusion, Mass and molar transport by convection, summary of mass and molar fluxes, Shell mass balance, boundary conditions, Examples, Equations of continuity, summary of multicomponent equations of change, Examples
- Dimensional analysis, Time-dependent diffusion, Steady state transport in binary boundary layers, Time-smoothed equations of change and velocity profiles, Empirical expressions for turbulent momentum flux; turbulent flow in ducts etc., Time-smoothed equations of change and temperature profiles for turbulent flow in tubes, Time-smoothed concentrations and equation of continuity and applications

Text Book:

1. Bird, Stewart and Lightfoot, 'Transport Phenomena', John Wiley & Sons, 2002, 2nd ed.

Reference Books:

1. Fox and McDonald, 'Introduction to fluid dynamics,' John Wiley & Sons, 2000, 5th ed.
2. Holman, J.P., 'Heat transfer', McGraw Hill, 1997, 8th ed.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
ME 625	Computational Fluid Dynamics	3	0	2	4

Evaluation Scheme (Theory)					Evaluation Scheme (Practical)			
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation/ Additional Continuous Evaluation*	Total Marks**	Mid Term Test - I	End Term Test	Class Participation/ Additional Continuous Evaluation*	Total Marks**
20	20	50	10	100	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Course Syllabi (Theory):

- **Mathematical modeling:** Governing equations of fluid flow and heat transfer; Introduction to discretization methods: Finite difference and finite volume methods for heat transfer problems; Time stepping methods for unsteady problems; Solution techniques for system of algebraic equations; Grid generation techniques; Solution techniques for Navier-Stokes equation; Finite element method for heat transfer and fluid flow problems; Turbulence modeling.
- **Introduction:** Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.
- **Classification and Overview of Numerical Methods:** Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods.
- **Finite Difference Technique:** Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of f.d. method.
- **Finite Volume Technique:** Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem.
- **Finite Element Methods:** Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications.
- **Methods of Solution:** Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform.
- **Time integration Methods:** Single and multilevel methods; predictorcorrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems.

- **Numerical Grid Generation:** Numerical grid generation; basic ideas; transformation and mapping.
- **Navier-Stokes Equations:** Explicit and implicit methods; SIMPLE type methods; fractional step methods.
- **Turbulence modeling:** Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.

Text Books:

1. Richard Pletcher, John Tannehill and Dale Anderson, `Computational Fluid Mechanics and Heat Transfer 3e', CRC Press, 2012
2. H.K. Versteeg and W. Malalasekera, `An introduction to computational fluid dynamics: The finite volume method 3e', Pearson Education, 2007.
3. Charles Hirsch, `Numerical Computation of Internal and External Flows', Vol.1 (1988) and Vol.2 (1990), John Wiley & Sons.

Reference Books:

1. J. H. Fergiger, M. Peric, `Computational Methods for Fluid Dynamics 3e', Springer, 2002.
2. T. J. Chung `Computational Fluid Dynamics 2e', Cambridge University Press, 2010.
3. C. A. J. Fletcher, `Computational Techniques for Fluid Dynamics Vol. 1 and 2 2e', Springer, 1991.
4. S.V. Patankar, `Numerical Heat Transfer and Fluid Flow', Hemisphere, 1980.
5. J. D. Anderson Jr., `Computational Fluid Dynamics', McGraw-Hill International Edition, 1995.
6. Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. (1997). Computational Fluid Mechanics and Heat Transfer. Taylor & Francis.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE611 (Elective-1)	Energy Engineering	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Sources of Energy; Energy Conversion and Conservation; Energy efficiency, energy services; Plant engineering, environmental compliance and alternative energy technologies; Power generation by steam, Hydroelectric, Diesel oil, Nuclear fission and Natural gas, Co-generation of power. Selection of power generation process; Energy Economic Analysis, Energy Auditing and Accounting, Energy minimization; Energy Loads; Application in building design, HVAC, lighting, refrigeration, etc. to both reduce energy loads and increase efficiency of current systems; Energy production, conversion, transference, distribution, and utilization; Sustainability; Energy Management; Climate Change and Climate Modeling; Carbon Sequestration and Carbon reduction targets;

Text Books:

1. Albert Thumann, D. Paul Mehta, “Handbook of Energy Engineering”, Fairmount Press Inc., 2008
2. Roger A. Hinrichs, Merlin H. Kleinbach, “Energy: Its uses and the environment”, Cengage Learning, 5th edition, 2011

References:

1. Tyler Hicks, “ Handbook of Energy engineering Calculations”, McGraw Hill Professional, 2011
2. Francis, W and M.C. Peter, “Fuels and fuel technology”, Pergamon Press, 1980.
3. Nagpal, G.R, “Power Plant Engineering”, Khanna Publishers, 1973
4. Rused, C. K., Elements of Energy Conservation , McGraw-Hill Book Co., 1985

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE612(Elective-1)	Non – Conventional Energy Sources	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Introduction: Energy scene of supply and demand in India and the world, energy consumption in various sectors, potential of non-conventional energy resources. Detailedstudy of the following sources with particular reference to India.

Solar Energy: Solar radiation and its measurement, limitations in the applications of Solar Energy, Solar collectors – types, and constructional details. Solar water heating, applications of Solar Energy for heating, drying, space cooling, water desalination, solar concentrators, photovoltaic power generation using silicon cells.

Bio-Fuels: Importance, combustion, pyrolysis and other thermo chemical processes forbiomass utilization. Alcoholic fermentation, anaerobic digestion for biogas production.

Wind Power: Principle of energy from wind, windmill construction and operational details and electricity generation and mechanical power production.

Tidal Power: Its meaning, causes of tides and their energy potential, enhancement of tides, power generation from tides and problems. Principles of ocean thermal energy conversion (OTEC) analysis and sizing of heat exchangers for OTEC.

Geothermal Energy: Geo technical wells and other resources dry rock and hot aquiferanalysis, harnessing geothermal energy resources.

Energy Storage and Distribution: Importance, biochemical, chemical, thermal, electric storage. Fuel cells, distribution of energy.

Text/Reference Books:

1. Rai,G.D,Non-conventional Energy Sources, Khanna Publishers, Delhi.
2. Twiddle, J. Weir, T. “Renewable Energy Resources,”Cambridge University Press, 1986.
3. Kreith, F. and Kreider, J. F., “Principles of Solar Engineering,”McGraw Hill, 1978.
4. Duffie, J. A., Beckman, W. A., “Solar Engineering of Thermal Processes,”John Wiley, 1980.
5. Veziroglu, N., “Alternative Energy Sources,”Volume 5 & 6, McGraw-Hill, 1978.
6. Sarkar, S., “Fuels and Combustion,”2nded., Orient Longman, 1989.
7. Sukhatme, S. P., “Solar Energy,”2nded., Tata McGraw-Hill, 1996.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE613(Elective-1)	Energy Conservation & Management	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Energy conservation, Growth and demand of energy, Energy availability, Comparison of specific energy use in select industry, Potential and status of energy in India, Energy saving potential in industries, Potential of energy efficiency in India, Energy available for industrial use and the role of conservation, Energy management and policy, Comprehensive energy conservation planning (CECP), Definition and principles of energy conservation, Energy conservation technologies, Cogeneration concept and scope, Energy audit and management, Energy conservation in utilities.

Text Books:

1. Energy Conservation In Process Industry, W. F. Kenny Energy Engineering and Management, AmlanChakrabarti - Prentice hall India 2011

Reference Books:

1. Energy Management Principles, CB Smith, - Pergamon Press, New York,
2. Bureau of energy efficiency, Hand outs New Delhi
3. Energy Management Hand Book, W. C. Turner. John Wiley and sons
4. Handbook on Energy Efficiency, TERI, New Delhi, 2009
5. Energy Auditing and Conservation; Methods, Measurements, Management & Case Study, Hamies, - Hemisphere Publishing , Washington, 1980.
6. Industrial Energy Management & Utilization, Write, Larry C - Hemisphere Publishers, Washington, 1998.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE614(Elective-1)	Process Plant Simulation	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Introduction, Mathematical Modeling, Chemical Systems Modeling, Modular Approaches to Process Simulation, Equation Solving Approach
- Decomposition of Networks, Convergence Promotion, Physical and Thermodynamic Properties, Optimization Techniques
- Specific Purpose Simulation, Dynamic Simulation

Text Books:

1. B V Babu, “Process Plant Simulation”, Oxford University Press, India (2004).

Reference Books:

1. Godfrey C Onwubolu and B V Babu, “New Optimization Techniques in Engineering; Springer-Verlag, Germany (2004).
2. William L Luyben, “Process Modeling, Simulation and Control for Chemical Engineers”, McGraw Hill Publishing Company, New York, 2nd Edition (1990).
3. R G E Franks, “Modeling and Simulation in Chemical Engineering”, John Wiley & Sons Inc., New York (1972).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE615(Elective-1)	Biochemical Engineering	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Various aspects of Biochemical Engineering, The structure of cells and Important cell types, Lipids, Polysaccharides, Nucleotides, Proteins etc.
- Reaction mechanisms, Comparison with chemical catalysis, Michaelies-Menten and Briggs-Haldane kinetic models. Various methods for kinetic parameter evaluation, Enzyme inhibition, Inhibition kinetic models, Application to drug industries, Physico-chemical factors influencing enzyme activity. Enzyme deactivation and kinetic models.
- Immobilized enzyme technology: Methods of immobilization; Immobilized enzyme kinetics; Analysis of external and intraparticle mass transfer, Terminology; Metabolic reaction coupling: ATP & NAD; Carbon catabolism and various pathways; Aerobic and anaerobic respiration.
- Stoichiometry of growth and product formation, Isolation of pure culture, Strain improvement by mutation, protoplast fusion and recombination DNA technique, Introduction, Ideal Reactors for Kinetics measurements, Biomass growth, Substrate uptake and product formation Kinetics measurements: Steady state and transient growth, Structured and unstructured kinetic models.
- Death kinetics, Mass and heat transfer in bioreactors, gassed reactors, immobilized and cell reactor systems, Ideal & non-ideal bioreactors, Modes of reactor operations: Batch, Fed-batch & continuous, Design of bioreactor, fermenter, Sterilization: Batch & Continuous, instrumentation, control, optimization, process scale-up, criteria and correlations
- Filtration, Centrifugation, Sedimentation, Emerging technologies for cell recovery, Extraction, Sorption, Cell disruption method, Precipitation, Coagulation, Flocculation, Dialysis, Electrodialysis, Reverse osmosis, Ion exchange, HPLC, Chromatography and fixed-bed adsorption, Membrane separations, and Electrophoresis, Complete commercial bioprocess: Commercial enzymes, antibiotics and Organic acids, Bioprocess economics and feasibility studies

Text Books:

1. 'Biochemical Engineering Fundamentals' by J. E. Bailey & D. F. Ollis (1987) 2nd Ed., McGraw Hill International Edition

References Books:

1. 'Bioprocess Engineering: Basic Concepts' by Michael L. Shuler & F. Kargi (2003) Prentice-Hall.
2. 'Principles of fermentation technology' P. F. Stanbury& A. Whitaker (1984), Pergamon Press.
3. Chemical Engineering, Vol. 3 by Coulson & Richardson (1998), Asian **Books**.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE621(Elective-II)	Process Design Decisions	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Introduction, Nature of Process Synthesis & Analysis, Energy Integration Analysis, Engineering Economics for Conceptual Design
- Economic Decision Making, Input Information and Batch vs. Continuous, Input-Output Structure of the Flow sheet, Recycle Structure of the Flow sheet
- Separation System, Cost Diagrams & Quick Screening of Process Alternatives, Preliminary Process Optimization, Process Retrofits

Text Books:

1. James M. Douglas, "Conceptual Design of Chemical Processes", McGraw Hill, New York, International Edition (1988).

Reference Books:

1. Max Stone Peters, Klaus D. Timmerhaus, and Ronald West "Plant Design and Economics for Chemical Engineers", McGraw Hill, New York, 5th Edition (2002).
2. Warren D. Seider, J. D. Seader, and Daniel R. Lewin, "Product & Process Design Principles: Synthesis, Analysis, and Evaluation", John Wiley & Sons, New York, 2nd Edition (2004).
3. Robin Smith, "Chemical Process Design", International Editions, McGraw Hill, Singapore (2000).
4. Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, "Analysis, Synthesis, and Design of Chemical Processes", International Edition, Prentice Hall, New Jersey (1998).
5. Dale F. Rudd, and Charles C. Watson, "Strategy of Process Engineering", John Wiley & Sons, New York (1968).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE622 (Elective-II)	Mathematical Methods in Chemical Engineering	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Ordinary differential equations (ODE) – Solution of first order and secondorder differential equations, simultaneous ODEs. Solution by LaplaceTransformation. Series solution method.

Complex Algebra: Introduction; The complex number; the Argand diagram;principle values; Algebraic operations on the Argand diagram; Conjugatenumbers; De Moivere's theorem; the nth roots of unity; complex numberseries; Trigonometrical exponential Identities; Derivatives of a complexvariable; Analytic functions; complex variable and Cauchy's theorem, Laurent'sexpansion, and theory of residues. Laplace inverse by Contour integration,Bromwich's integral formula.

Functions and Definite Integrals: Introduction, error function, gammafunction, beta function, other tabulated functions defined by integrals; Definiteintegrals by contour integration.Vector Analysis: Addition and Subtraction of vectors, Multiplication of vectors,Scalar triple product, Vector triple product, Differentiation of vectors, Partialdifferentiation of vectors, Divergence, Continuity equation, Curl of a vector,Line integral, Vector area and Surface integral, Gauss' Divergence theorem,Green's theorem. Spherical and Cylindrical coordinate systems. Streamfunction, Creeping flow arounda sphere.

Partial differential equations (PDE)- Classifications of PDEs, FormulatingPDEs, Separation of variables method, Orthogonal functions and Sturm-Liouville conditions, The Laplace transform method.

Text/Reference Books

1. Jenson, V.G. and Jeffreys, G.V., "Mathematical Methods in Chemical Engineering,"2nd ed., Academic Press, New York, 1977.
2. Rice, R. G. and Do, D. D., "Applied Mathematics and Modeling for Chemical Engineers", John Wiley & Sons, New York, 1995.
3. Varma, A. and Morbidelli, M., "Mathematical Methods in Chemical Engineering," Oxford University Press, New York, 1997.
4. Kreyszig, E., "Advanced Engineering Mathematics," 8th ed., John Wiley & Sons, 2000.
5. Mickley, H.S., Sherwood, T.K., and Reed, C.E., "Applied Mathematics in Chemical Engineering," McGraw-Hill, 1957.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE623 (Elective-II)	Corrosion Engineering	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Corrosion Engg., environments, corrosion damage, classification of corrosion, Introduction, corrosion rate expressions. Electrochemical aspects: Electrochemical reactions, polarization, passivity.
- Environmental effects: effects of oxygen and oxidizers, velocity, temperature, corrosive concentration, galvanic coupling. Metallurgical and other aspects: metallic properties, economic considerations, importance of inspection.
- Uniform attack, galvanic corrosion, Crevice corrosion:environmental factors, mechanism, combating crevice corrosion, Filiform corrosion, Pitting: pit shape and growth, autocatalytic nature of pitting, solution composition, velocity, metallurgical variables; evaluation of pitting damage, prevention
- Intergranular corrosion: Austenitic stainless steels, weld decay, control for austenitic stainless steels, knife-line attack, integranular corrosion of other alloys, Selective leaching: dezincification-characteristics, mechanism, prevention: graphitization, other alloy systems, high temperatures
- Erosion corrosion: surface films, velocity, turbulence, impingement, galvanic effect, nature of metal or alloy; combating erosion corrosion, cavitation damage, fretting corrosion.
- Stress corrosion: crack morphology, stress effects, time to cracking, environmental factors, metallurgical factors, meachanism, multi-environment charts, classification of mechanisms, methods of prevention, corrosion fatigue, Hydrogen damage: characteristics environmental factors, hydrogen blistering, hydrogen embrittlement, prevention
- Materials; Metals and alloys: cast irons, carbon steels and irons, Low alloy steels, Stainless steels, various metals and their alloys, Non-metallics: rubbers and other elastomers, various thermoplastics and thermosettings, laminates and reinforced plastics
- Other non-metallics: various ceramics, carbon and graphite, Materials selection: metals and alloys, non-metallics, Alteration of environment: changing mediums, lowering temperature, decreasing velocity, removing oxygen or oxidizers, changing concentration; Inhibitors of various types, Design: wall thickness, design rules, Cathodic and anodic protection, Coatings: metallic and other inorganic coatings; organic coatings

Text Book:

1. Fontana M.G., "Corrosion Engineering", McGraw-Hill Companies, 1986, 3rd ed.

Reference Book:

1. Mattsson E., "Basic Corrosion Technology for Scientists and Engineers", The Institute of Materials, London, 1996, 2nd ed.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE624 (Elective-II)	Pulp & Paper Technology	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Selection of pulp and paper making raw materials, Wood Anatomy- identification, Preparation of wood chips, Chip screening, Storage and chip conveying, Chemical composition of fibrous raw materials, Chemical Pulping, Mechanical Pulping, Chemical thermo-mechanical (CTP) processes, Waste Paper Pulping, Bleaching and washing, Chemical Recovery, Description of various grades of pulp & paper, Mechanical and chemical properties of pulp, Paper making, cellulose derivatives- preparation & end use, Environmental aspects in pulp and paper industry.

Text Books/Reference Books:

1. Handbook of pulping and papermaking by Christopher J. Biermann, 2nd ed Academic press 1996.
2. Handbook for Pulp and Paper Technologists by G. A. Smook 3rd edition, Angus Wilde Publications, 1992

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE625 (Elective-II)	Fertilizer Technology	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Introduction

- Fertilizer industry in India
- Feed stock and raw materials

Phosphatic fertilizers

- Ground rock phosphate
- Single Super-phosphate

Technology/ Production of Fertilizer Products

- Phosphoric acid
- Nitric acid
- Sulphuric acid
- Ammonia

Modernization of Older Plants (Revamping)

Urea

Potassic Fertilizers

Complex fertilizers

Text Books

1. “Handbook on Fertilizer Technology”, Fertilizer Association of India, Sixth Edition, 2001.

Reference Books

1. G. F. Austin, “Shreve’s Chemical Process Industries”, 5th Edition, McGraw Hill Publication.
2. “Ammonia: Principles and Industrial Practice”, Max Appl, Wiley-Vch, 1999.
3. "Fertilizer Manual", United nations, New York, 1967.
4. "Synthetic Nitrogen Products", Gary_Maxwell, Springer Science, 2005.

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INSTITUTE OF ENGINEERING AND TECHNOLOGY

4 Year B. Tech Programme

(Branch: Chemical Engineering)

Batch 2014-18

SEMESTER-SEVENTH

Detailed Syllabus

&

Scheme of Examination

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE701	Optimization of Chemical Processes	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Formulation of the objective function.

Unconstrained single variable optimization: Newton, Quasi-Newton methods, polynomial approximation methods.

Unconstrained multivariable optimization: Direct search method, conjugate search method, steepest decent method, conjugate gradient method, Newton's method.

Linear Programming: Formulation of LP problem, graphical solution of LP problem, simplex method, duality in Linear Programming, Two-phase method.

Non Linear programming with constraints: Necessary and sufficiency conditions for a local extremum, Quadratic programming, successive quadratic programming, Generalized reduced gradient (GRG) method.

Applications of optimization in Chemical Engineering.

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", Witey Eastern, New Delhi, 1985.
3. Gupta, S.K., "Numerical Methods for Engineers", New Age, 1995.
4. Beveridge, G.S. and Schechter, R.S., "Optimization Theory and Practice", McGraw-Hill, New York, 1970.
5. Rekllaitis, G.V. Ravindran, A. and Ragsdell, K.M., "Engineering Optimization –Methods and Applications" John Wiley, New York, 1983.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE702	Process Utilities and Industrial Safety	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Water: Water resources, Storage and characterization, Conditioning.

Steam: Boilers, Steam Handling and distribution, Steam nozzles, Condensate utilization, Steam traps, Flash tank analysis, Safety valves, Pressure reduction valves, Desuperheaters.

Air: Air compressors, Vacuum pumps, Air receivers, Piping systems, Different types of ejectors, Air dryers.

Hazards and Safety: Classifications and assessment of various types of hazards, Risk assessment methods, General principles of industrial safety, Hazards due to fire, explosions, Toxicity and radiations, Industrial hygiene, Maximum allowable concentration and threshold limit value, Protective and preventive measures in hazards control, Introduction to industrial safety regulations.

Case studies of hazardous incidents in industries using HAZOP.

Text Books

1. Vasandhani, V. P., and Kumar, D. S, Heat Engineering, Metropolitan Book Co. Pvt. Ltd. (2009).
2. Crowl, D.A. and Louvar, J.F., Chemical Process Safety-Fundamentals with Applications, Prentice Hall, (2002).

Reference Books

1. Peavy, H. S., and Rowe, D. R, Environmental Engineering, McGraw Hill (1985).
2. Banerjee, S., Industrial Hazards and Plant Safety, Taylor & Francis 2003).
3. Lees, F.P., Prevention in Process Industries. Butterworth's (1996).
4. Sanders, R. E. Chemical Process Safety-Learning from Case Histories, Oxford (2005).
5. Perry, R.H., and Green, D. W, Chemical Engineer's Handbook, McGraw Hill (1997).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE703	Industrial Pollution Abatement	3	0	2	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	20	40	15	25	100

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Introduction: Industrial pollution, Different types of wastes generated in an industry, Different water pollutants, Air pollutants and solid wastes from industry, Their effects on living and non-living things,Environmental regulatory legislations and standards, Importance of industrial pollution abatement, Concept of sustainable development, Green house gases, Global warming and climate change.

Water Pollution: Identification, quantification and analysis of wastewater, Classification of different treatmentmethods into physico-chemical and biochemical techniques, Physico-chemical methods, General concept ofprimary treatment, Liquid-solid separation, Design of a settling tank, Neutralization and flocculation, Biological methods, Concept of aerobic digestion, Design of activated sludge process, Concept of anaerobic digestion, Biogas plant layout, Different unit operations and unit processes involved in conversion of highly polluted water to potable standards.

Air Pollution: Classification of air pollutants, Nature and characteristics of gaseous and particulate pollutants, Analysis of different air pollutants, Description of stack monitoring kit and high volume sampler, Atmospheric dispersion of air pollutants, Gaussian model for prediction of concentration of pollutant down wind direction, Concept of temperature inversion, Plume and its behavior, Concept of effective stack height, Operatingprinciples and simple design calculations of particulate control devices like gravity settling chamber, cyclone, bag filters, electrostatic precipitators and scrubbers, Brief concepts of control of gaseous emissionsbyabsorption, adsorption, chemical transformation andcombustion.

Solid Wastes: Analysis and quantification of hazardous and nonhazardous wastes, Treatment and disposal of solid wastes, Land filling, Leach ate Treatment, Incineration.

Environmental Management System: Environment impact assessment, Its concept and constituents, Environmental audit, ISO-14000 system.

Syllabus (Practical)

Characterization of waste water (pH, BOD, COD, Nitrate, Phosphate, Solids, Turbidity, Alkalinity, Hardness, Dissolved oxygen and fluoride), Ambient air quality measurement by high volume sampler (Particulate, SOX, NOX), Gas analysis with Orsat apparatus, Determination of sludge volume index.

Text Books:

1. Peavy, H.S., Rowe, D.R., and Tchobanoglous, G. Environmental Engineering, McGraw Hill International (1985).
2. Metcalf & Eddy, Wastewater Engineering, Tata McGraw-Hill Education Private Limited (2009).

Reference Books:

1. Masters, G.M., Introduction to Environmental Engineering and Science, Prentice hall off India, (2008).
2. De Nevers, N., Air Pollution Control Engineering, McGraw-Hill (2000).
3. Rao, C.S., Environmental Pollution Control Engineering, Wiley Eastern (2010).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
HS701	Principle of Economics	3	0	0	3

Evaluation Scheme (Theory)					Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation/ Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	50	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory)

Definition of Economics and role of economics in Engineering and Technology; Basic economic terms; The economy, working of an economy, kinds of an economy and its basic problems; Laws of Demand and Supply and market Equilibrium; Elasticity of demand its measurements and application, Production function and law of Variable Proportion and Law of Returns to Scale; Concepts of cost and revenue, short run and long run cost function; Profit maximization hypothesis, Price and output determination under Perfect Competition, Monopolistic competition and Monopoly.

Measurement of macroeconomic aggregates, National Income, Consumption, saving and investment function; Macroeconomic issues: Inflation, Unemployment and Economic growth International aspects of macroeconomics; Foreign Exchange rate and Balance of payments.

Text Book(s)

T.R. Jain and M.L. Grover, “Economics for Engineers”, V. K. (India) Enterprises

Reference Book(s)

1. D N Dwivedi “Principles of Economics”, Vikas Publishing House Pvt Ltd.
2. G. Mankiew. Economics Principles and Applications. Cengage Learning

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE711 (Elective-III)	Advanced Heat Transfer	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Steady-state conduction – multiple dimensions, Unsteady-state conduction, Principles of convection, forced and natural convection
- Radiation heat transfer, Condensation & boiling heat transfer, Heat exchanger analysis & design
- Heat Exchanger Networks

Text Book:

1. Holman J. P., "Heat Transfer", 9th Ed., Tata McGraw-Hill, New Delhi, 2004.

Reference Books:

1. Kern, D. Q., "Process Heat Transfer," McGraw-Hill, New York, 1950.
2. Douglas, J. M., "Conceptual Design of Chemical Processes", McGraw-Hill, New York, 1988.
3. Perry J. H. "Chem. Engrs Hand Book", 7th Ed., McGraw-Hill, 2001.
4. Frank Kreith& Mark. S. Bohn, "Principles Of Heat Transfer", 4th Ed., Harper & Row Publishers, New York, 1986.
5. Kays, W. M. &Crowford, M. E., "Convective Heat and mass Transfer", 3rd Ed., McGraw-Hill, 1993.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE712(Elective-III)	Energy Integration Analysis	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Energy Targeting, Area Targeting, Unit Targeting, Cost Targeting, ΔT_{min} Optimization, Logic of Pinch Technology
- The Continuous Targeting Algorithm, Diverse Pinch for Different Heat Transfer Coefficient, Continuous Heat Cascades for Diverse and Conventional Pinch Concepts
- Basic Pinch Design Method, MER Networks for Multiple Utilities and Multiple Pinches, Balanced Grid Networks, Constrained Heat Exchanger Networks
- Loop Breaking and Path Relaxation, Systematic Energy Relaxation Approach, Eliminating Units Using Bypass, Design Tools to Achieve Targets, Evolution of Constrained Networks, Cost Evolution of Networks
- HRAT and EMAT, Pseudo-pinch Design Method, Flexible Pinch Design Method, Compensation Principle Design Method
- Basic Thermal Design, Kern's Method, Bell-Delaware Method, Rapid Design Algorithm, Area Targeting Based on Pressure Drops, The Interfacing Methodology, Stream Pressure Drop Optimization
- Retrofit by Inspection, Retrofit-Fixed Heat Transfer Coefficient, Retrofit-Specified Pressure Drops, Debottlenecking
- Distillation and Evaporation Processes, Reaction Processes
- Utility Targeting and MER Networks, Area Targeting, Optimal HEN through Superstructure, Network Load Optimization

Text Book:

1. Uday V Shenoy, "Heat Exchanger Network Synthesis: Process Optimization by Energy and Resource Analysis", I edition, Gulf Publishing Company, Houston Texas, 1995.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE713 (Elective-III)	Process Intensification	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- History, Philosophy, Principles, Definition, need of process, Intensification, Process Intensifying Equipment, Process Intensifying Equipments, Examples of their application on the commercial scale
- Use of high gravity fields, HiGee Reactor, Spinning Disc Reactors, Principles, Micro-reactors, Microchannel, heat exchangers, Monolithic, catalyst and reactors, Concept and principle, Reactive distillation, extraction, precipitation, adsorption, absorption, and fermentation-pervaporation,
- Adsorptive distillation, Membrance, absorption and stripping, Principles, Integration of reaction, heat and mass transfer, Reverse flow reactor, Reverse flow reactor, Reactive distillation, Extractive, fermentation, Membrane Reactors
- Methodology, Application, De-bottle-necking, Principles, Design, Integrated plants, Traditional Approach, Strategies

Text Book:

1. AndrzejStankiewicz, Jacob A. Moulijn. Re-engineering the Chemical Processing Plant: Process Intensification, Marcel Dekker, Inc., New York, 2004.

Reference Book:

1. Joseph Mizrahi, Developing an Industrial Chemical Process: An Integrated Approach, CRC Press, 2002.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE714(Elective-III)	Computer Aided Design in Chemical Engineering	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Role of Computer-Aided Design (CAD) in chemical industry;. Approaches to CAD, potential and pitfalls; Estimation of physical/chemical properties application to the design of chemical processing units; Evaluation of the design, sensitivity analysis; Applications include use of computer programs (software packages and student-created programs for the design of process units, e.g. distillation, towers, multiple effect evaporators, multicomponent absorbers, heat exchanger networks, etc.)

Text Book

1. Sinnot R K, “Chemical Engineering Volume 6, Chemical Engineering Design (Coulson and Richardson's Chemical Engineering Series)”, Third Edition, Butterworth Heinemenn (An imprint of Elsevier science)
2. Aspen Plus manual, CHEMCAD manual

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE715 (Elective-III)	Petroleum Refining & Petrochemicals	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

1. Origin & formation of petroleum, reserves &deposites of world, Indian refineries, oil & gas scene, HBJ gas grid, crude and gas reserves, Hydrocarbon series, isomeric compounds, composition of petroleum, sulpher compounds.
2. Evaluation of Petroleum, Thermal properties of petroleum fractions, Important products – properties and test methods, Desalting of Crudes, Heating of Crude – Pipe still heaters, Distillation of petroleum (Atmospheric, Vacuum), Thermal cracking, Catalytic cracking, Catalytic reforming, Naphtha cracking, Delayed coking, Hydro cracking, Hydro treating, Alkylation, Isomerisation.
3. Source of Asphalt (Bitumen), Air blowing of bitumen, Up gradation of heavy crudes, Natural gas, Petroleum, Classification of Petrochemicals., Ethylene, Propylene, Butylenes, Acetylene, Butadienes, Chloroprene, Cyclohexane, BTX.
4. Synthesis gas, Methanol, Ethanol, EO, PO, IA, Acetone, Allyl alcohol, Glycerol, Acrylonitrile, Acrylic acid and Derivatives, Phenol, Aniline, Nylon Monomers, Polyester Monomers, Styrene, Other monomers, Plastics, Rubbers, Fibers, Resins, Detergents, Pesticides, Dyes, Protein, Explosives.

Text Books:

1. B.K. BhaskaraRao, “Modern Petroleum Refining Processes”, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 4th ed., 2002.
2. Maiti S., “Introduction to Petrochemicals”, Oxford & IBH Publishing Co., Pvt., Ltd., New Delhi, 2nd Ed., 2002.

Reference Book:

1. Nelson, W.L., “Petroleum Refinery Engineering”, McGraw-Hill Kogakusha, Ltd., Tokyo, 4th ed., (International student edition), 1958.
2. Watkins, R.N., “Petroleum Refinery Distillation”, Gulf Pub. Company, Houston, 2nd ed., 1979.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE716 (Elective-III)	Nanofluid Engineering	3	1	0	4

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Introduction: Fundamentals of cooling, Fundamentals of nanofluids, Development of nanofluids, Experimental discoveries, Mechanisms and models for enhanced thermal transport.

Synthesis of Nanofluids: General issues of concern, Synthetic methods: Common issues of concern, Variety in nanomaterials, Microemulsion-based methods for nanofluids, Solvothermal synthesis, Synthesis using supports, Magnetic nanofluids, Inert gas condensation, Anisotropic nanoparticles, Other nanofluids.

Conduction Heat Transfer in Nanofluids: Conduction heat transfer, Measurement of thermal conductivity of liquids, Thermal conductivity of oxide nanofluids, Temperature dependence of thermal conductivityenhancement, Metallic nanofluids, Nanofluids with carbon nanotubes.

Theoretical Modeling of Thermal Conductivity in Nanofluids: Simple mixture rules, Maxwell's approach, Particle distributions, Particle geometries, Symmetrical equivalent medium theory, Matrix–particle interfacialeffects, Interfacial thermal resistance, Dynamic models of thermal conductivity in nanofluids, Near-field radiation model.

Convection in Nanofluids: Fundamentals of convective heat transfer, Convection in suspensions and slurries, Convection in nanofluids, Analysis of convection innanofluids, Numerical studies of convection in nanofluids, Convective simulation for chip cooling application.

Boiling of Nanofluids: Fundamentals of boiling, Pool boiling of nanofluids, Critical heat flux in pool boiling of nanofluids, Other investigations related to boilingof nanofluids.

Applications and Future Directions: Applications of nanofluids, Liquid cooling, Tribological applications, Biomedical applications, other potential applications, Applied research in nanofluids.

Text Books:

1. Das, S. K., Choi, S. U. S., Yu, W., and Pradeep, T., Nanofluids, John Wiley & Sons (2008).
2. Surya Kumar Saripella, Nanofluid heat transfer enhancement in engineering applications, University of Illinois at Urbana-Champaign (2007).

Reference Books:

1. Wilson, M., Kannangara ,K., Smith, G., and Simmons,M., Nanotechnology: Basic Science and Emerging Technology, Chapman & Hall (2004).
2. Liqiu Wang, Advances in Transport Phenomena, Springer (2009).

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE721(Elective-IV)	Fluidization Engineering	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- Types of adsorption; type of isotherm; adsorption kinetics; adsorbent, Basic modeling approach with suitable boundary condition, Upcoming adsorption techniques and their modeling approach; application of adsorption in different areas
- Introduction to cryogenic systems; low temperature properties and phenomena; application as separation and purification technique, Gas liquefaction, different air liquefaction cycles
- Cryogenic distillation; refrigeration systems, techniques for storage and transportation, Classification of membrane based on structures, flow, fabrication *etc.*Gas and liquid phase separation; pervaporation; liquid membrane; membrane reactor, Modeling approach; design considerations and applications
- Introduction to bio-kinetics, Types of bio-reactors and different techniques for bio-separation, Modeling approach, design considerations and applications, Concept of reactive distillation; supercritical fluid extraction, Modeling approach, design considerations and applications

Text Book:

1. Gupta, R. K. and A. K, Ghoshal "Advanced Separation Technology", *EDD Notes**, BITS, Pilani, 2000.

Reference Books

1. Seader, J. D. and E. J. Henley, " Separation Process Principles", *John Wiley & Sons, Inc. (Wiley India (P) Ltd.,* New Delhi), 2nd Ed., 2006.
2. Ruthven, D. M., S. Farooq and K. S. Knaebel, "Pressure Swing Adsorption", *VCH Publishers*, NY, 1994.
3. Barron, R., "Cryogenic Systems", *Oxford University Press*, NY, 2nd Ed. 1985.
4. Bailey, J. E. and D. V. Ollis, "Biochemical Engineering Fundamentals", *Mc-Graw Hill*, 1986.
5. Ruthven, D. M. "Principles of Adsorption and Adsorption Processes", John Wiley and Sons, 1984.
6. Mukhopadhyay M., "Natural Extracts using Supercritical Carbon Dioxide", *CRC Press*, LLC, Boca Raton, Florida, USA, 2000.
7. Research Papers from Refereed Journals / Resources.
8. Dynamic addition of reference material will be shared.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE722(Elective-IV)	Advanced Separation Processes	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Adsorption-based separation, Concept of adsorber design, application of adsorption in different areas; cryogenic separation, Gas liquefaction, different air liquefaction cycles, Cryogenic distillation, refrigeration systems, techniques for storage and transportation; Membrane separation, Gas and liquid phase separation, pervaporation, liquid membrane, membrane reactor; biotechnology-based separation, Introduction to bio-kinetics, Types of bio-reactors and different techniques for bio-separation; Recent advancements on the above areas and new concepts such as simulated moving bed adsorption, thermally coupled pressure swing adsorption, reactive distillation, bio-filtration, supercritical fluid extraction

Text Book:

1. Seader, J. D. and E. J. Henley, " Separation Process Principles", *John Wiley & Sons, Inc. (Wiley India (P) Ltd.,* New Delhi), 2nd Ed., 2006.

Reference Books:

1. Ruthven, D. M., S. Farooq and K. S. Knaebel, "Pressure Swing Adsorption", *VCH Publishers*, NY, 1994.
2. Barron, R., "Cryogenic Systems", Oxford University Press, NY, 2nd Ed. 1985.
3. Bailey, J. E. and D. V. Ollis, "Biochemical Engineering Fundamentals", Mc-Graw Hill, 1986.
4. Ruthven, D. M. "Principles of Adsorption and Adsorption Processes", John Wiley and Sons, 1984.
5. Mukhopadhyay M., "Natural Extracts using Supercritical Carbon Dioxide", CRC Press, LLC, Boca Raton, Florida, USA, 2000.
6. Research Papers from Refereed Journals / Resources.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE723(Elective-IV)	Sugar Technology	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Composition of cane and cane juice, Aim of clarification , clarification efficiency; Cabonation process, Double sulphitation process, PhosphitationProcess;Various juice heaters, Various clarifiers , Vacuum Filters.Milk of lime preparation, Sulphur burner and preparation of SO_2 Gas; Juice Sulphitation , Syrup Sulphitation , Use of different chemicals; Aim of evaporation, Different types of evaporators, Different types of vapour bleeding System , Steam economy , DEVC cum Quad System, Quintuple System; Scale formation, De scaling, Cleaning procedure.Different types of condensers, Condensates, Ammonia gas, Entrainment; Syrup / Melt Clarification , Filtrate Clarification.

Text Books

1. Introduction To Cane Sugar Technology by G.H. Jenkin
2. Principles of Sugar Technology by P. Honig.

References:

1. Hand Book of Sugar Technology by R.B.L. Mathur.
2. Hand Book of Cane Sugar Engineering by E. Hugot.
3. Cane Sugar Hand Book by Meade And Chen.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE724(Elective-IV)	Pharmaceutical Engineering	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

Introduction, Pharma engineering and its significance, unit operations and unit processes; Stoichiometry, General principles, material balance-tie substances, chemical reactions and molal units, rate process, steady, unsteady and equilibrium state, laws of combining weights, applications of gas laws, energy balance, fuels and combustion; Fluid Flow, Type of steady flow, Reynold number & its significance, types of pressure, viscosity, concept of boundary layers, total energy balance and total mechanical energy balance, losses in mechanical energy of fluids, basic equations of fluid flow, valves, flow meters, manometers and measurement of flow rate and pressure; Transportation of Materials, Solids- Bins, bunkers, conveyers, air transport, Liquids- Pipelines, fittings, valves, pumps, measurement of flowing liquids, Gases- Fans, blowers and compressors; Filtration, Theory and mechanism of filtration process, factors affecting rate of filtration, filter media, filter aids, types of filters, operation of filters, industrial filters-leaf filter, filter press, rotary filter, Edge filters etc, Mathematical problems on filtration, optimum cleaning cycle in batch filters, Applications in pharmacy. Centrifugation, Principle and theory of centrifugation, industrial centrifuges-perforated basket, centrifuge, sedimentation type centrifuge, continuous centrifuges etc. Mathematical problems, applications in pharmacy, Materials of Pharmaceutical Plant, Construction, Factors affecting the material selection for pharmaceutical plants, metals and nonmetals, corrosion and its prevention.

Text Books/References:

1. Elementary Chemical Engineering - Max S. Peters, Published by McGraw Hill BookCompany, New York, 1954
2. Perry's Chemical Engineer's Handbook - Robert H Perry, Green D.W., Maloney J.O.7th Edition, 1998, McGraw – Hill Inc., New York.
3. Tutorial Pharmacy by Cooper & Gunn, ed. S.J.Carter, CBS Publishers & Distributors, Delhi, 6th Edition, 2000.
4. Unit Operations of Chemical Engineering, 5th edition - McCabe, Smith &Harriott, McGraw – Hill Inc., New York.
5. Pharmaceutical Engineering – K.Sambamurthy, 2002 NAI (P) Ltd., Delhi.
6. Pharmaceutics : The Science of Dosage Form Design - M.E. Aulton.
7. The Theory & Practice of Industrial Pharmacy – Lachman L., Lieberman H.A. &Kanjig J.L., 3rd edition, 1990 Varghese Publishing House, Bombay.
8. Alfonso G. Remington: The Science & Practice of Pharmacy. Vol.I& II 20th edition, 2000. Lippincott, Williams & Wilkins Philadelphia.
9. Paradkar A.R. Introduction to Pharmaceutical Engineering, 3rd Edition, 2001, NiraliPrakashan, Pune.

10. Subramanyam C.V.S., Thimma J, Suresh S.S. et. al., Pharmaceutical Engineering : Principles and Practice, 2002, VallabhPrakashan, Delhi.
11. P.J.Shah, A Textbook of Engineering Drawing Vol. I and II, 6th Edition, 2003, Ahmedabad
12. Engineering Drawing, 34th edition, N.D.BhattCharutar Publishing House, 1994
13. Engineering Drawing & Graphic Technology, 13th edition by Thomas E. French, Charles J. Vierch, Rebot J. Foster, McGraw Hill International Edition, New Delhi, 1972
14. Filtration in Pharma. Industry by Tehodere H. Meltzed, Marcel Dekker Inc., New York, 1987
15. Introduction to Chemical Engineering by Walter L. Badger & Julius T. Banchero, Mcgraw Hill International edition, New Delhi, 1955.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE725(Elective-IV)	Chemical Vapor Deposition	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

A simplified multi-step fab sequence, Applications of thin films, thin film deposition, chemical vapor deposition, advantages and disadvantages of various methods of chemical vapor deposition; Process Fundamentals, definition, CVD reaction rate control, heat transport; APCVD Fundamentals, use of APCVD in semiconductor processing, typical APCVD continuous belt reactor., deposition area boundaries, APCVD process gases, equipments; LPCVD Fundamentals, the pressure and temperature characteristics of the LPCVD process, key components of a typical LPCVD system, two practical advantages of LPCVD processing, major types of LPCVD reaction chambers and the advantages and disadvantages; PECVD Fundamentals, plasma, ion, RF, radical, excitation, relaxation, ionization, recombination, plasma potential and plasma shielding, regions of various plasma discharge.

Text Books:

1. D.M. Dobkin, Michael K. Zuraw, “Principles of Chemical Vapor Deposition”, Kluwer Academic Publishers, 2003
2. Anthony C. Jones, Michael L. Hitchman , “Chemical Vapour Deposition”, RSC Publishisng, 2009

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
CHE726(Elective-IV)	Scale-Up and Pilot Plant Methods in Chemical Engineering	3	0	0	3

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation*	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
20	20	40	10	10	100	-	-	-	-	-

*Additional Continuous Evaluation: Quizzes/Assignments/Presentations/Practical Records/Mock Interviews/others

Syllabus (Theory):

- **Scale up:** Description and evolution of a process system, Introduction to Scale up procedures, Dimensional analysis, Similitude.
- **Reactors for Fluid Phase Processes Catalyzed by Solids**: Pseudo-homogeneous and heterogeneous models, Two-dimensional models, Scale up considerations.
- **Fluid-fluid Reactors:** Scale-up considerations in packed bed absorbers andbubble columns,
- Applicability of models to scale-up.
- **Mixing Processes:** Scale-up relationships, Scale-up of polymerization units, Continuous stages gas-liquid slurry processes, Liquid-liquid emulsions.
- **Fluidized Beds:**Major scale-up issues, Prediction of performance in large equipment, Practical commercial experience, Problem areas.
- **Solid-Liquid Separation Processes**: Fundamental considerations, Small scale studies forequipment design and selection, Scale-up techniques, Uncertainties.
- **Continuous Mass Transfer Process**: Fundamental considerations scale-up procedure for distillation, Absorption, Stripping and extraction units.

Text Books:

1. Marko Zlokarnik, Scale-up in chemical engineering, Wiley-VCH (2006).
2. R.E. Johnstone and M.W. Thring, Pilot Plants, Models and Scale-up Methods in Chemical Engineering, McGraw-Hill (1957).

Reference Books:

1. Colin Divall, Sean Johnston, Scaling up: the Institution of Chemical Engineers and the rise of a new profession, Springer (2000).
2. Bisio, A. and Kabel, R.L., Scale-up of Chemical Processes, John Wiley (1985).

SEMINAR

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
Seventh	Seminar	0	0	4	2

S. No.	Evaluation Component	Duration (Hours)	Marks (100)	Nature of Component
1.	Presentation	Weekly	25	Open Book
2.	Report(Soft Copy)	Weekly	25	Open Book
3.	Assignment	Continuous	10	Open Book
4.	Final Presentation		20	Open Book
5.	Final Report(Hard Copy)		20	Open Book

Syllabus (Practical)

Operation Procedure

1. Student has to devote full semester for SEM701 course.
2. Student has to report to the Supervisor regularly.
3. Seminars s evaluation has to be carried out in the presence of a two member Committee comprising.
4. Experts in the relevant area constituted by the Supervisor.

Final Seminar Report to be submitted has to be in formal hard bound cover bearing of the Institute emblem.

Reference Books:

Based on literature survey to be done with peer reviewed journals and magazines.

Course code	Course Title	Teaching Scheme			
		L	T	P	Credits
PS801	Practice School - II	-	-	-	16

Evaluation Scheme (Theory)						Evaluation Scheme (Practical)				
Mid Term Test - I	Mid Term Test - II	End Term Test	Class Participation	Additional Continuous Evaluation	Total Marks	Mid Term Test - I	End Term Test	Class Participation	Additional Continuous Evaluation *	Total Marks
-	-	-	-	-	-	-	-	-	-	-

** Duration for practice school is Five and a half month

Course Syllabi:

This course is for five and half months (summer and one semester) in VII or VIII Semester. The objective of this programme is to provide the students, an opportunity to work on live projects of corporate world in various fields. During this programme, they will work on real world applications of their curricula through organizational function of their choice. The students are expected to be involved directly in problem solving efforts of specific interest to the host organization. The learning of PS-I will help them in completing PS-II successfully.

Evaluation Scheme:

S. No.	Evaluation Component	Marks (100) (Weightage %)
1	Quiz-I	4
2	Quiz-II	4
3	Group Discussion-I	4
4	Group Discussion-II	4
5	Seminar-I	4
6	Seminar-II	4
7	Diary-I	4
8	Diary-II	4
9	Observation-I	4
10	Observation- II	4
11	Mid Term Evaluation (Project Report and Presentation/Viva)	20
12	Final Evaluation (Project Report and Presentation/Viva)	40