Bharati Vidyapeeth University

College of Engineering

Department of Chemical Engineering

CBCS Structure: 2014- 2015

Sem VII and Sem VIII

Bharati Vidyapeeth University
Faculty of Engineering and Technology
Programme: B. Tech. (Chemical) - Semester VII - 2014 Course

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
						Continuous Assessment								
		L	P/D	T	End Semester Examination	Unit Test	Attendance	Assignments	TW/O	TW/P	Total	Theory	P/D	Total
1	Elective-III	3	2	-	60	20	10	10	50	-	**150**	3	1	**4**
2	Chemical Process Equipment Design– II	3	2	-	60	20	10	10	50	-	**150**	3	1	**4**
3	Plant Utilities and Process Safety	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
4	Process Dynamics and Control	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
5	Multiphase Reaction Engineering	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
6	Industrial Training	-	-	-	-	-	-	-	50	**-**	**50**	-	3	**3**
7	Project [Stage I]	-	4	-	-	-	-	-	100	-	**100**	-	4	**4**
Total		**15**	**10**	**-**	**300**	**100**	**50**	**50**	**250**	**50**	**800**	15	10	**25**

Bharati Vidyapeeth University
Faculty of Engineering and Technology
Programme: B. Tech. (Chemical) - Semester VIII - 2014 Course

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
						Continuous Assessment								
		L	P/D	T	End Semester Examination	Unit Test	Attendance	Assignments	TW/O	TW/P	Total	Theory	P/D	Total
8	Elective-IV	3	2	-	60	20	10	10	50	-	**150**	3	1	**4**
9	Plant Design, Project Engineering and Costing	3	2	-	60	20	10	10	50	-	**150**	3	1	**4**
10	Industrial Management	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
11	Chemical Process Modeling and Simulation	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
12	Seminar	-	-	2	-	-	-	-	50	-	**50**	2	-	**2**
13	Project [Stage II]	-	6	-	-	-	-	-	200	-	**200**	-	8	**8**
Total		**15**	**6**	**8**	**240**	**80**	**40**	**40**	**350**	**50**	**800**	14	11	**25**

Total Credits
Semester VII : 25
Semester VIII : 25
Grand Total : 50

Elective-I	Elective-II
1. Combustion Engineering	1. Biofuel Technology
2. Advanced Material Science	2. Polymer Technology
3. Multiphase Flow	3. Food Technology
4. Rheology	4. Nanomaterials
Elective-III	**Elective-VI**
1. Petroleum Refinery Engineering	1. Hazardous Waste Management
2. Membrane Separation	2. Bio-separations
3. Fuel Cell Technology	3. Energy Engineering
4. Advanced Oxidation Processes	4. Green Technology

Bharati Vidyapeeth University

College of Engineering

Department of Chemical Engineering

CBCS Syllabus: 2014-2015

Sem VII and Sem VIII

CHEMICAL PROCESS EQUIPMENT DESIGN-II			
Designation: Professional Core			
Course Pre-requisites:			
Students should have basic knowledge of			
1	Unit Operations involved in chemical engineering		
2	Heat transfer and Mass transfer and Mechanical operation equipments.		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week		End Semester Examination: 60 Marks	Theory : 03
Drawing : 2 Hour /Week		Unit Test: 20 Marks	Drawing: 01
Total : 5Hours/Week		Continuous Assessment: 20 Marks	Total credits: 04
		Term work / practical:50 Marks	
		Total :150 Marks	
Course Outcomes:			
After completion of the course, students would be able to			
1.	Design evaporator and crystallizers.		
2.	Design Dryers and Filters.		
3.	Design different columns used in distillation/Absorption.		
4.	Identify and design different packings used in packed columns.		
5.	Calculate height of packing, column diameter in packed columns.		
6.	Understand importance of process safety and Hazard Analysis.		
Topics covered			
UNIT-I	**Evaporators & Crystallizers** Classification of vaporizing equipment, evaporators such as kettle, thermosiphon, vertical, horizontal etc., Chemical evaporators, natural circulation & forced circulation evaporators, the calculation of chemical evaporators, crystallizers, types of crystallizers, design considerations. Case studies on evaporators.		**(06 Hours)**
UNIT-II	**Filters & Dryers:**		**(06 Hours)**

	Various types of filters like vacuum filters, pressure filters, centrifuges and rotary drum filters, design of rotary drum filters, including design of drum, shaft, bearing and drive system. Types of dryers, batch type dryers, continuous dryers.	
UNIT-III	**Tray Column Design** Design of plate column- distillation columns, design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate Contactors, plate hydraulic design.	**(06 Hours)**
UNIT-IV	**Packed Column Design** Choices of packing, types of packing, packed bed height (distillation and absorption), HETP, HTU, NTU, Cornell's method, Onda's method, column diameter, column internals, column auxiliaries.	**(06 Hours)**
UNIT-V	**Piping Design I** Definition and Application of Piping, Classification of pipe, Piping Material Specifications, Manufacturing Method, Weight and Size Standards STD , Extra Strong XS , Double Extra Strong XXS etc. Pressure Temperature Rating System, Pipe Fittings, Types of Flanges, Types of Valves,	**(06 Hours)**
UNIT-VI	**Piping Design II** Codes and Standards, Piping elements, Pipe Hydraulics and Sizing, Mechanical Design, Fundamentals Piping Drawing, Basics Development of Plot Plan, Equipment and Piping Layout, Stress Analysis Static and Dynamic, Selection and Design of Supports and Expansion Joints,Transient Fluid flow Analysis. Friction Factor, Moody Diagram, Minor Losses in Piping ,Equivalent Length Method & Loss Coefficient Method,	**(06 Hours)**

Assignments

1.	Write a report on different evaporators and crystallizer
2.	Types of Dryers and filters.
3.	Designing of Distillation column.
4.	Designing of Absorption column.
5.	Importance of piping design.

6.	Pipe sizing and supports
7.	Report on Equivalent Length Method & Loss Coefficient Method,
8.	Solve old (last five years) question papers with reference to particular topic.
9.	Prepare a model for any of the equipment
10.	Prepare a report on advance equipments which are newly introduced in the current year.
11.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
12.	Solve old (last ten years) GATE question papers with reference to design subject.
13.	Group discussion on the recent advances in equipment design
14.	Write a report on your visit to research and development laboratory of national/international repute.
15.	Technical interview based on the knowledge of design
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Term Work:	
Term work will consist of the Practicals and drawings listed below, out of which any eight are to be done by students. Any one drawing in Autocad.	
1.	Design and drawing of evaporator.
2.	Design and drawing of crystallizer.
3.	Design and drawing of rotary filter.
4	Detailed design and drawing of piping layout.
5.	Detailed design and drawing of spray dryer..
6.	Detailed design and drawing of distillation column.
7.	Detailed design and drawing of absorption column..
8.	Study various packings.
9.	Design and calculations of packed column.
10.	Study the contains of stress analysis of pipes.
11.	Detailed design and drawing of piping supports.
Text Books/References:	
1.	Joshi. M.V, and Mahajani. V.V, “Process Equipment Design,” 3rd Edn. Macmillan India Limited, New Delhi, 1996

2.	Bownell, L.E., and Young, E.M., "*Process Equipment Design"*, Wiley Eastern, 1968.
3.	Sinnott. R.K, Coulson & Richardson's, "Chemical Engineering", Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.
4.	Bhattacharya B C, Chemical Equipment Design , CBS publishers.
5.	Dawande S D, " Process Equipment Design" DENETT publishers

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

MULTIPHASE REACTION ENGINEERING		
Designation: Professional Core		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Thermodynamics	
2	Transport Processes	
TEACHING SCHEME	**EXAMINATION SCHEME**	**CREDITS ALLOTTED**
Lectures : 3 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
	Unit Test : 20 Marks	Practical: 01
	Continuous Assessment : 20 Marks	Total credits: 04
	Total :100 Marks	

Course Outcomes:

After completion of the course students would be able to

1	Recognize the importance of multiphase reactors.
2	Determine chemical reaction equilibrium constant and rate controlling step for heterogeneous system.
3	Recognize the effect of system and operating parameters on the hydrodynamics of multiphase reactors.
4	Recognize the significance of mixing and determine extent of mixing in multiphase system
5	Determine the effect of system, geometric, and operating parameters on heat and mass transfer coefficients.
6	Enumerate the effect of hold up in the design of multiphase reactors

Topics covered

UNIT-I	**Introduction to Multiphase Reactor Engineering** Types, Classification, Application of Industrial Importance. Two case studies	**(06 Hours)**
UNIT-II	**Thermodynamics and kinetics** Notable industrial heterogeneous systems and thermodynamic role. Application of equilibrium criteria to chemical reactions. The Gibbs energy change and equilibrium constant. Estimation of equilibrium constant for heterogeneous system by defining standard state of the phases involved. Determination of rate controlling step: intrinsic kinetics for heterogeneous systems	**(06 Hours)**
UNIT-III	**Hydrodynamic Characteristics** Hydrodynamic characteristics of different multiphase reactors: Mechanically	**(06 Hours)**

	Agitated Contactors (MAC), Bubble Columns, Slurry Reactors, Fluidized Beds, Loop Reactors and Modified Versions	
UNIT-IV	**Mixing Studies** Effect of geometrical, system, and operating parameters on phase mixing in multiphase reactors. Quantification of phase mixing. Development of a mathematical model.	**(06 Hours)**
UNIT-V	**Heat Transfer and Mass Transfer Studies** Effect of geometrical, system, and operating parameters on heat transfer coefficient in multiphase reactors. Quantification of heat transfer coefficient. Application of correlations available to different multiphase reactors. Experimental techniques used for estimation of mass transfer coefficient and selection of suitable technique for a multiphase reactor. Effect of geometrical, system, and operating parameters on mass transfer coefficient in multiphase reactors. Quantification of mass transfer coefficient. Application of correlations available to different multiphase reactors.	**(06 Hours)**
UNIT-VI	**Design Aspects of Multiphase Reactors** Pressure drop, Fractional phase hold- up, mass and heat transfer coefficient, extent of mixing, etc.	**(06 Hours)**

Assignments:	
1.	Enumerate any one industrial relevant multiphase system
2.	Refer any one recently published article related to multiphase system and make presentation
3.	Estimate the power requirement for a given impeller
4.	Visit to any chemical process industry to study atleast one multiphase system
5.	List the pressure measurement tools available in the market
6.	List and enumerate physical significance of the empirical correlations available in the literature to estimate liquid dispersion coefficient.
7.	List and enumerate physical significance the empirical correlations available in the literature to estimate mass transfer coefficient.
8.	Refer any review article perati
9.	Technical interview based on the knowledge of analytical techniques.
10.	List out all the principles of the analytical techniques.
11.	Perform any one chromatographic technique.
12.	Find out different types of proteins with structure.
13.	Prepare a report on downstream processing.
In addition to these above stated assignments concerned faculty member may design his/her own	

assignments.	
Text Books/References:	
1	L. K. Doraiswamy and M. M. Sharma, "Heterogeneous Reactions", 2nd Edition, Volume I and II.
2	G. B. Tatterson, "Fluid Mixing and Gas Dispersion in Stirred Reactors", 10th Edition, Academic Press, London, 1994
3	W. D. Deckwer, "Bubble Column Reactors", Cambridge University Press, New York, 2000
4	DiazoKunji and O. Levenspiel, "Fluidization Engineering", 2nd Edition, Butterworth Heinemann, 1991.
5	J. F. Devidson and Harrison, " Fluidization", 10th Edition, Academic Press, London, 1994
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

PLANT UTILITIES AND PROCESS SAFETY			
Designation: Professional Core			
Course Pre-requisites:			
Students should have knowledge of			
1.	Chemical Technology, Chemical Process Industries		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 3 Hours/Week		End Semester Examination : 60 Marks	Theory : 03
		Unit Test : 20 Marks	Total credits : 03
		Continuous Assessment : 20 Marks	
		Total : 100 Marks	
Course Outcomes:			
After completion of the course students will be able to			
1.	Identify the common utilities required for Chemical Plant.		
2.	Express various types of boilers and their selection.		
3.	Analyze the importance of insulation and air pressure in process.		
4.	Identify and analyze the hazards.		
5.	Integrate the theoretical and practice knowledge to understand hazards activities.		
6.	Implement the safety designs and procedures.		
Topics covered			
UNIT - I	**Identification of common plant utilities** Role and importance of pant utilities in chemical plants, Water, compressed air, steam, vacuum, refrigeration, venting, flaring and pollution abating. Water and its quality, storage and distribution for cooling and fire fighting, Water resource management.		**(06 Hours)**
UNIT - II	**Steam Generation and Utilization** Steam generation and its application in chemical process plants, distribution and utilization; Types of boilers and their operation; steam economy, Steam condensers and condensate utilization, Steam generation by utilizing process waste heat using thermic fluids, Selection and sizing of boilers; waste heat		**(06 Hours)**

	boilers.	
UNIT - III	**Compressors, blowers and Vacuum Pumps** Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Creation of low pressure/vacuum by pumps and ejectors. **Refrigeration and HVAC** fundamentals of refrigeration, refrigerant management and safety, Selection of refrigerants; Processes of HVAC, Psychometric Chart and Air-Conditioning System, Ventilation and Indoor Air Quality.	**(06 Hours)**
UNIT - IV	**Elements of Safety** Elements of safety, safety and site selection; Plant layout and unit plot planning; Definition of risk and hazard, Identification and assessment of the hazards, distinction between hazards and risk, Industrial hygiene, toxicological studies, Hazard operability (HAZOP) hazard analysis (HAZAN); Safety Integrity Level (SIL) Studies; Technology selection and transfer, choosing the right process.	**(06 Hours)**
UNIT - V	**Safety in Chemical Processes** Introduction, Chemical Process classification, Process design and safety parameters. Safety parameters in the process design of phenol from cumene, safety in polyvinyl chloride plant. **Chemicals and their Hazards** Acetonitrile, acetyl chloride, butyl amine, acrylamide, acrylonitrile, allyl alcohol, benzene, bromine, isopropyl alcohol, acetaldehyde, ethylene oxide, butane, n-hexane, anhydrous ammonia, acetone, toluene, p-xylene, acetic acid, monochloro benzene, oleum, carbon monoxide.	**(06 Hours)**
UNIT - VI	**Safety Procedures and Designs** Process Safety Hierarchy, Process Safety Strategies, Managing Safety, Safety Reviews and Accident Investigations, Designs for Process Safety, Inherently Safer Designs, Controls: Double Block and Bleed, Safeguards or Redundancy, Block Valves, Explosion Suppression, Designs for Runaway Reactions.	**(06 Hours)**

Tutorials/Assignments:	
The internal assessment shall consist of minimum SIX assignments from the following list	
1.	Prepare a report on safety issues of any one particular industry.
2.	Prepare Utility Line Diagram (ULD) for typical process.
3.	Write a report on HAZOP study of one particular hazard.
4.	Prepare a report on the color codes for utility pipelines in chemical plants.
5.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments
6.	Write a report on " Importance of Industrial Hygiene in Chemical Industry"
7.	Group discussions on any of the following topics: a) Importance of various utilities in chemical industries. b) Process safety in petroleum industry c) HAZOP Vs HAZAN
8.	Design a manual for application of utilities for various plants.
9.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
10.	Write a technical report on HAZAN study of any one particular threat.
11.	Elaborate the role of safety engineer in Chemical industry.
12.	Organizing a industrial visit to nearby industry to understand the plant utilities and safety measures.
13.	Write a report on your visit to research and development laboratory of national/international repute.
Text Books/ References:	
1.	Chemical Process Plants-Managing Plant Utilities, Volume One
2.	Chemical Process Plants-Managing Plant Utilities, Volume Two
3.	Robert McDowall, "Fundamentals of HVAC Systems", Butterworth-Heinemann Elsevier, First edition 2006
4.	John J. McKetta, "Encyclopedia of Chemical Processing and Design", Volume 44 CRC Press, 1993

5.	Daniel A. Crowl, Joseph F. Louvar, “Chemical Process Safety Fundamentals with Applications”, Prentice Hall, Third Edition, 2011
6.	Trevor A. Kletz, “Hazop & Hazan: Identifying and Assessing Process Industry Hazards”, Fouth Edition, CRC Press, 1999.

Syllabus for Unit Test:	
Unit Test - I	UNIT– I, II, and III
Unit Test - II	UNIT– IV, V, and VI

PROCESS DYNAMICS AND CONTROL			
Designation: Professional Core			
Course Pre-requisites:			
Students should have			
1.	Basic knowledge of Mathematics.		
2.	Process Instrumentation and Instrumental Methods of Analysis		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3Hours/Week		End Semester Examination: 60 Marks	Theory : 03
Tutorial : 2 Hour /Week		Unit Test: 20 Marks	Practical : 01
Total: 5 Hour /Week		Continuous Assessment: 20 Marks	Total credits: 04
		TW/Practical: 50 marks	
		Total : 150 Marks	
Course Outcomes:			
After completion of the course students will be able to			
1.	To give details of basic control action and develop mathematical models for control purpose.		
2.	To illustrate behavior of chemical processes.		
3.	To elucidate transient response of system.		
4.	To describe stability of the system.		
5.	To analyze frequency response of process.		
6.	To apply knowledge for controller selection and tuning.		
Topics covered			
UNIT-I	**Introduction:** Block diagrams, closed loop and open loop control systems, Basic control actions. **Open Loop Response of Simple Systems:** Dynamics of first order systems using transfer functions; Various first order responses such as, a thermometer bulb. General response to step, ramp, impulse, and sinusoidal inputs; Concentration and temperature responses of a stirred tank		**(06 Hours)**

UNIT-II	**Dynamic Behavior of Chemical Processes:** Linearization of liquid level systems**:** Response of a pressure system, second order systems, the manometer; Response of interacting and non interacting systems. Transfer functions and the input-output models. Dynamics and analysis of first, second and higher order systems.	**(06 Hours)**
UNIT-III	**Transient Response of Control Systems:** Servo and regulated operation, General equations for the transient response, proportional control of a signal capacity process; Integral control, Proportional-integral control and derivative action.	**(06 Hours)**
UNIT-IV	**Stability:** Concept of stability, Stability criterion, Routh test for stability. **Root Locus Analysis:** Concept of root locus, Locus diagram.	**(06 Hours)**
UNIT-V	**Frequency Response Analysis:** First order systems, Bode diagram, and Complex numbers to get frequency response. Nyquist plot.	**(06 Hours)**
UNIT-VI	**Advanced Control Schemes:** Controller selection and tuning, Control valve characteristics and sizing, cascade control, Feed forward and ratio control. Introduction of digital control system.	**(06 Hours)**

List of Experiments:

Term work will consist of the experiments listed below, of which at least eight should be performed in laboratory by the students.

1.	To study the closed loop pressure control for P control action and calculate offset.
2.	To study the closed loop pressure control for PI action PID action.
3.	To study optimizing performance for pressure control trainer by using tuning technique with help of PID action.
4.	To study closed loop system for servo problem having PI action consideration.
5.	To study the closed loop flow controller
6.	To study the closed loop level controller

7.	To study the ratio controller
8.	To study the cascade controller
9.	Root locus analysis on software (Ex. MATLAB)
10.	Bode plot on software (Ex. MATLAB)
11.	Nyquist plot on software (Ex. MATLAB)
12.	PID control loop simulation for a first order process (Ex. SIMULINK)
Assignments:	
1.	Students have to visit chemical industry and prepare a detailed report on various controllers used in industry.
2.	Watch NPTEL video and make report on various topics in process dynamics and control
3.	Group discussions on controllers used for chemical processes.
4.	To find Transfer Function for 1^{st} order and 2^{nd} order process.
5.	Draw the Control Loop and Block Diagram for different chemical processes.
6.	Solve numerical questions in last three year question papers.
7.	Write note on Advance Controllers.
8.	Explain Digital Controllers.
9.	Explain IMC Controller in Detail.
10.	Explain MPC Controller in Detail.
11.	Explain process Identification of any Chemical Process in detail
12.	Explain Optimal control of any one Chemical Process.
Text Books/References:	
1	G. Stephanopoulos, *Chemical Process Control: An introduction to theory and practice,* Prentice Hall, New Jersey, 1984.
2	P. Harriott, *Process Control, Reprint of text,*ed. Tata McGraw Hill, 1983.
3	D. R. Coughanowr, *Process system analysis and control,* 2nded, McGraw Hill, 1991.
4	Seborg, D.E., Edgar, T.F. and Mellichamp, "Process dynamics and control," Wiley, New York, D.A. 2003.
Syllabus for Unit Test:	

Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

CHEMICAL PROCESS MODELING AND SIMULATION			
Designation: Professional Core			
Course Pre-requisites:			
Students should have basic knowledge of			
1	Heat transfer, Mass transfer, Chemical reaction engineering, Process Dynamics and Control		
2	Process Calculation		
3	Mathematics including integration and derivation		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week		End Semester Examination: 60 Marks	Theory : 03
Practical : 2 Hour /Week		Unit Test: 20 Marks	Practical: 01
Total : 5Hours/Week		Continuous Assessment: 20 Marks	Total credits: 04
		Term work / practical:50 Marks	
		Total :150 Marks	
Course Outcomes:			
After completion of the course students would be able to			
1	Express mass balance, energy balance and momentum balance equation for various chemical process systems.		
2	Express models for heat transfer equipment such as double pipe heat exchangers, shell and tube heat exchanger, etc.		
3	Develop models for distillation columns, etc.		
4	Develop models for reaction equipment such as batch reactor, CSTR, etc.		
5	Recognize simulation approaches.		
6	Simulate model equations using numerical methods.		
Topics covered			
UNIT-I	**Introduction to modeling:** Introduction, definition of modeling, different types of models, applications of mathematical modeling, principles of formation, lumped model, distributed parameter model, Fundamental laws: continuity equation, energy equation,		**(06 Hours)**

	equations of motions, transport equations, equations of state, chemical kinetics.	
UNIT-II	**Modeling of Heat transfer equipment:** Double pipe heat exchanger, shell and tube heat exchanger, two heated tanks, single component vaporizer, steady-state heat Conduction through a hollow cylindrical pipe, heat transfer with coil	**(06 Hours)**
UNIT-III	**Modeling of distillation columns:** Ideal binary distillation column, multi component non-ideal distillation column, batch distillation with holdup, flash distillation, packed column design	**(06 Hours)**
UNIT-IV	**Modeling of reactors:** Two phase CSTR with heat removal, series of isothermal constant holdup CSTRs, CSTRs with variable holdups, Gas phase-pressurized CSTR, Non–Isothermal CSTR, Batch reactor, gas liquid bubble reactor, semi-batch reactor.	**(06 Hours)**
UNIT-V	**Introduction to simulation:** Introduction to simulation, definition of simulation, approaches of simulation: modular approaches, equation-solving approach, decomposition of networks: tearing algorithms, algorithms based on the signal flow graph, algorithms based on reduced digraph.	**(06 Hours)**
UNIT-VI	**Simulations using numerical methods:** Use of numerical methods to solve mathematical model equations of Gravity flow tank, Three CSTRs in series, Non-isothermal CSTR, Binary distillation column, Multi-component distillation column, Batch reactor.	**(06 Hours)**

Assignments	
1	Write a report on the importance of modeling with reference to the process industries.
2	Solve old (last five years) question papers with reference to particular topic.
3	Discuss the importance of modeling and simulation w. r. t. science and engineering
4	Prepare a report on application of modeling and simulation.
5	Give fifteen minute presentation (seminar) on particular topic and prepare a report.
6	Obtain any industrial data for modeling and simulation.
7	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.

8	Discuss different software available for modeling and simulation.
9	Write a technical report on your visit to a process industry with respect to modeling.
10	Group discussion on the recent advances in simulation software.
11	Prepare a report on modeling and simulation of all different chemicals reactors.
12	Technical interview based on the knowledge of Modeling simulation.
13	Students may take any industrial case e.g. manufacturing of Maleic anhydride and solve this case using standard simulation software like Aspen Plus, HYSIS
In addition to these above stated assignments concerned faculty member may design his/her own assignments.	
Term Work:	
Term work will consist of the practicals listed below, out of which any eight practicals are to be performed in laboratory by the students.	
1	Study of gravity flow tank.
2	Study of Batch reactor
3	Simulation of CSTR
4	Simulation of bubble point temperature
5	Simulation of distillation column.
6	Simulation of heat exchanger
7	Simulation of first order reaction system in batch reactor.
8	Simulation of first order reaction system in CSTR
9	Study of a reversible reaction in a batch reactor.
10	Simulation of any model equation.
11	Study of CSTR combination in first order reactions.
	For simulation, faculty member may use any suitable simulation software like MATLAB, ASPEN, CHEMCAD, etc. In addition to these above stated practicals concerned faculty member may design his/her own practicals.
Text Books/References:	
1	W. L. Luyben, Process Modeling Simulation and Control for Chemical Engineers, McGraw Hill, 1990.

2	S.C. Chapra, R.P. Canale, Numerical Methods for Engineers, 6th Edition, Tata-McGraw Hill Publications, 2012.
3	R.E.G. Franks, Modeling and Simulation in Chemical Engineering, WielyIntrscience, NY, 1972.
4	B.V. Babu, Process Plant Simulation, Oxford University Press, NY 2004.
5	D. Himmelblau, K.B. Bischoff, Process Analysis and Simulation, John Wiley & Sons, 1968

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

INDUSTRIAL MANAGEMENT		
Designation: Professional Core		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Concept of Management.	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
	Unit Test: 20 Marks	Drawing: 00
Total:3 Hours/Week	Continuous Assessment: 20 Marks	Total credits: 03
	Total :100Marks	

Course Outcomes:	
After completion of the course, students would be able to	
1.	Know the types of business.
2.	Understand the types of organization
3.	Understand the forms of ownership.
4.	Know the concepts of material management.
5.	Know the concepts quality management.
6.	Know the various acts.

Topics covered		
UNIT-I	**Outline of Business** Types of Business, Industrial sectors Globalization Management Process, Principles of Management, Functions of Management	**(06 Hours)**
UNIT-II	**Organizational Management** Organization, Types of organization, Departmentation, Principles of Organization, Forms of ownership	**(06 Hours)**
UNIT-III	**Financial Management** Financial Management- Objectives & Functions, Capital Generation &	**(06 Hours)**

	Management, Budgets and accounts, Taxation (Excise Tax, Service Tax, Income Tax, Value Added Tax and Custom Duty)	
UNIT-IV	**Materials Management** Inventory Concept, its classification, functions of inventory, ABC Analysis, Economic Order Quantity Concept, graphical representation, determination of EOQ,Standard steps in Purchasing, Modern Techniques of Material Management, Material Resource Planning (MRP), Enterprise Resource Planning (ERP)	**(06 Hours)**
UNIT-V	**Quality Management** Quality Management System, Quality Control, Quality Circle, Quality Assurance, Total Quality and TQM, Kaizen,5'S',6 Sigma	**(06 Hours)**
UNIT-VI	**Industrial Legislation and Industrial Safety** Safety Management, Causes of accidents, Types of Industrial Accidents, Preventive measures, Safety procedures Factory Act, Air (Prevention and Control of Pollution) Act, Minimum Wages Act, Workman Compensation Act.	**(06 Hours)**

Assignments

1.	Types of business.
2.	Globalization in India
3.	Different principals of management.
4.	Various types of organization
5.	Various forms of ownership
6.	Capital Generation for an organization.
7.	ABC Analysis.
8.	Standard purchase
9.	Material Resource Planning (MRP), Enterprise Resource Planning (ERP)
10.	Concepts of quality management.
11.	Total Quality Management (TQM)
12.	Kaizen approach in Quality management.
13.	5'S',6 Sigma

14.	Factory Act
15.	Minimum Wages Act, Workman Compensation Act
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Text Books/References:	
1.	Khanna. O.P., "Industrial Engineering & Management" Dhanpat Rai & Sons New Delhi.
2.	Banga T. R. and Sharma S.C. "Industrial Engineering & Management" Khanna Publication
3.	*Saxena*, S.C." Business Administration & Management" SahityaBhavan Agra
4.	Newman W.H., Warren E. K. and McGil A. R., "The process of Management" Prentice- Hall
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

PLANT DESIGN PROJECT ENGINEERING AND COSTING		
Designation: Professional Core		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Chemical Process Industry	
2	Chemical design	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
Practical : 2 Hour /Week	Unit Test: 20 Marks	Practical: 01
Total : 5Hours/Week	Continuous Assessment: 20 Marks	Total credits: 04
	Termwork / Oral :50 Marks	
	Total :150 Marks	
Course Outcomes:		
After completion of the course students would be able to		
1.	Select appropriate process for a project.	
2.	Differentiate the equipment and able to prepare specification sheet.	
3.	Learn basic economic concept, to understand and apply this concepts in the project works undertaken and to chemical engineering situation by solving problem.	
4.	Evaluate the project cost including capital investment, product cost and the total project cost.	
5.	Solve problem on profitability and breakeven analysis.	
6.	Control and schedule of the project using CPME/PERT technique, calculations.	
Topics covered		
UNIT-I	**Introduction:** Plant design : Design basis, process selection, material of construction, plant location ,plant layout and installation, safety ,start up ,shut down and operating guidelines ,Preliminary techno economic feasibility report .Complete engineering flowsheet drawing.	**(06Hours)**

UNIT-II	Optimization and feasibility of plant design, selection of process equipments: Standard versus special equipment selection criteria, and specification sheets. Importance of Laboratory development pilot plant, Indian boiler regulations, factories act.	**(06Hours)**
UNIT-III	Cost estimation: Cash flow and cumulative cash position for industrial operations, factors affecting estimation of investment and production cost, total capital investment, fixed and working capital investment &their estimations, type of estimates, cost indexes, method for estimating capital investment. Insurance.	**(06 Hours)**
UNIT-IV	Estimation of total product cost, Estimation of total product cost: manufacturing cost, general expenses, Manufacturing cost: direct production cost, fixed charges, plant overhead cost. Types of depreciation, Method for determining depreciation: straight line method, decline balance method, sum of the year digit method, shrinking fund method etc, payout period.	**(06 Hours)**
UNIT-V	Profitability, alternative investments and replacement: Methods for profitability evaluation, Evaluation of Break Even Point and its significance, % rate of return, Practical factors in alternative investment and replacement Studies	**(06 Hours)**
UNIT-VI	Scheduling and Networking of Project Planning of project schedule by BAR CHART, Inventory control scheduling project using CPM/PERT methods. Network diagramming, earliest start time and earliest finish time, Advantages of CPM, Cost to finish the project earlier than normal cost.	**(06 Hours)**

Assignments	
1.	Write a report on plant design for any company for current year.
2.	Write preliminary feasibility report for any industry.
3.	Draw complete engineering drawing for any process industry.
4.	Prepare specification sheet for equipments for any particular industry.
5.	Give power point presentation of different types of cost for industry.
6.	Draw a chart of how cash flow takes place in chemical industry.

7.	Analyze cost index for last ten years and how it changes.
8.	Understand basic concept of depreciation and apply to any chemical industry and calculate the values.
9.	Apply a critical-thinking and problem-solving approach towards factories act.
10.	Specify materials for construction and estimate the cost of investments for chemical industry.
11.	Write complete report for a chemical industry which should include all the factors related to cost estimation.
12.	Give power point presentation on knowledge of safety in chemical industry.
13.	Give power point presentation on importance of break even analysis.
14.	Prepare one network diagramming by using CPM method.
15.	Gove a power point presentation on CPM and PERT for any particular industry.
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Term Work:	
Term work will consist of drawing of sheets	
	Standard symbols as per IS code
1	Process flow diagram
2	Piping and Instrumentation diagram
3	Plant layout and elevations
4	Utility diagram
5	Piping GA drawing
6	Piping isometrics
7.	Draw any sheet by using Autocad.
Text Books/References:	
1.	M.S.Peters and Timmerhaus, “Plant design and Economics for Chemical Engineers”, McGraw Hill 3rd Edition.
2.	F.C. Vibrandt and C.E. Dryden, “Chemical Engineering Plant Design”, McGraw Hill Fifth Edition..
3.	Coulson & Richardson’s Chemical EngineeringVolume 6, Butterworth-Heinemann, 1999, 3rd Edition.

4.	Industrial Engineering and Management by O. P. Khanna Dhanpat Rai & Sons, 1985 7th Edition
5.	Project Engineering: Suhas Mokashi ,Mcmillan Publisher .

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

Bharati Vidyapeeth University

College of Engineering

Elective

Elective III: Advanced Oxidation Processes		
Designation: Elective		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Waste water treatment	
2	Engineering Chemistry	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
Practical : 2 Hour /Week	Unit Test: 20 Marks	Practical: 01
Total : 5Hours/Week	Continuous Assessment: 20 Marks	Total credits: 04
	Term work / Oral :50 Marks	
	Total :150 Marks	
Course Outcomes:		
After completion of the course students would be able to		
1.	Demonstrate the mechanism of various advanced oxidation processes (AOPs)	
2.	Understand the method of ozonation and photon induced AOPs	
3.	Learn the method of heterogeneous photocatalysis and its mechanism	
4.	Know the method of homogeneous and heterogeneous Fenton processes and its mechanism	
5.	Analyze emerging AOPs and their mechanism	
6.	Demonstrate the industrial applications of AOPs	
Topics covered		
UNIT-I	**Introduction to advanced oxidation processes (AOPs)** Conventional waste water treatment processes, Fundamentals and background of AOPs for water and wastewater treatment, basic reaction mechanism of AOPs, Role of hydroxyl radicals and their generation, Reaction kinetics and degradation mechanisms of organic pollutants by hydroxyl radicals, Effects of	**(06 Hours)**

	process parameters and scavenging media on degradation efficiency, oxidation potential of AOPs, merits and demerits of various AOPs	
UNIT-II	**Ozonation and Photo induced AOPs:** Ozonation: background and fundamentals, reaction kinetics and mechanisms, Application of homogeneous and heterogeneous catalytic ozonation in water treatment Fundamentals of UV irradiation, Absorption and bond dissociation energy, UV sources and their characteristics, choice of photo source–used in AOPs and their spectral distributions, mechanism of photo induced AOPs. Photo induced AOPs: Oxidation using ultraviolet irradiation and hydrogen peroxide (UV/H2O2), oxidation using ultraviolet irradiation and ozone (UV/Ozone), oxidation using combination of ultraviolet irradiation, hydrogen peroxide and ozone (UV/ H2O2 /Ozone).	**(06 Hours)**
UNIT-III	**Heterogeneous photo-catalysis** Fundamentals of semiconductor photo-catalysis, various semiconductor particles used in photocatalytic applications, visible light driven photo-catalysts, photocatalytic reactions and kinetic studies and introduction to nano photo-catalysis. Photocatalytic reactors, solar energy driven or artificial light photo reactors, solar collectors, design of slurry or supported catalyst reactors, comparing reactor efficiencies and reuse of catalyst.	**(06 Hours)**
UNIT-IV	**Homogeneous and heterogeneous Fenton processes** Fenton process, photo-fenton process, advanced fenton process, the mechanism of fenton based processes, merits and demerits of homogeneous and heterogeneous Fenton processes.	**(06Hours)**
UNIT-V	**Emerging AOPs** Electrochemical oxidation, Ultrasound processes; principles of sonochemistry and acoustic cavitation, ultrasound cavitation and its combination with other AOPs, synergistic and antagonistic effects, hydrodynamic cavitation and its combination with other AOPs.	**(06 Hours)**

UNIT-VI	**Industrial applications of AOPs** Application of AOPs for industries such as textile, petroleum, pharmaceutical, petrochemical industry etc., decontamination of ground water, cost or economic analysis of various AOPs	**(06 Hours)**

Assignments	
1.	Write a report on current scenario of advanced oxidation processes.
2.	Evaluate the use of solar or visible light driven photocatalysts.
3.	Estimate synergistic effect of combining AOPs with cavitation based processes
4.	Give power point presentation on semiconductor photocatalysis
5.	Analyze the industrial applications of AOPs.
6.	Understand the reaction mechanism of AOPs
7.	Apply a critical-thinking towards scale-up aspects of AOPs.
8.	Analyze recent advances in synthesis of mixed oxide photocatalysts.
9.	Write a technical report on your visit to a waste water treatment plant.
10.	Give power point presentation on the applications of emerging AOPs
11.	Group discussion on the recent advances in advanced oxidation processes.
12.	Make a complete chart of various operations involved in waste water treatment.
13.	Assess the environmental or safety norms for disposal of waste water.
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Term Work:	
Term work will consist of the Seminar :	
	Seminar should be based on recent advances in AOPs. Students may undertake studies in water and waste water treatment using AOPs. Design and scale-up aspects can be studied in detail. Termwork should be based on the technical report on these studies carried out by individual or small group of students.
Text Books/References:	
1.	Simon Parsons, Advanced oxidation processes for water and wastewater treatment, IWA Publishing,

	2004.
2.	Thomas Oppenlander, Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts, Wiley-VCH Publishing, 2003.
3.	Vincenzo Belgiorno, Vincenzo Naddeo and Luigi Rizzo, Water, wastewater and soil treatment by Advanced Oxidation Processes (AOP), Lulu Enterprises, 2011.
4.	Jean-Pierre Franc, Jean-Marie Michel, “Fundamentals of Cavitation”, Kluwer Academic Publishers, Dordrecht.
5.	T. J. Mason and J. P. Lorimer, “Applied sonochemistry: Uses of power ultrasound in chemistry and processing”, Wiley-VCH publishers.

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE III: FUEL CELL TECHNOLOGY					
Designation: Elective					
Course Pre-requisites:					
Students should have knowledge of					
1.	Chemistry, Physics, Thermodynamics				
TEACHING SCHEME:		**EXAMINATION SCHEME:**		**CREDITS ALLOTTED:**	
Lectures	: 3 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 03
Practical	: 2 Hour /Week	Continuous Assessment	: 40 Marks	Practical	: 01
		Term Work/Oral	: 50 Marks	Total credits	: 04
		Total	: 150 Marks		
Course Outcomes:					
After completion of the course students will be able to					
1.	Define the concept of fuel cell.				
2.	Express various types of fuel cell.				
3.	Distinguish between the fuel cell and electrochemical cell.				
4.	Express the thermodynamics of fuel cell system.				
5.	Learn the process of fuel processing				
6.	Develop enough skills to design systems or components of fuel cells.				
Topics covered					
UNIT - I	**Introduction to Fuel Cell Technology** Fuel cell definitions, Need of fuel Cell, Principal of fuel cell technology, Basics Electrochemistry of fuel cell, Calculation of cell potential: activities or concentrations, electrochemical potential; The movement of ions in solution: diffusion and migration, Conductivity and mobility, Liquid junction potentials, ion-selective electrodes.			**(06 Hours)**	
UNIT - II	**Classification of Fuel Cells** Alkaline Fuel Cells, Phosphoric Acid Fuel Cells, Solid Oxide Fuel Cells, Molten Carbonate Fuel Cells, Direct Methanol Fuel Cells, Proton Exchange			**(06 Hours)**	

	Membrane Fuel Cells	
UNIT - III	**Fuel Cell Components** Electrolytes, Catalysts, Current collector/ bipolar plate. **Fuel cell characterization** Possible ways of characterization, In-situ characterization especially I-V characteristics and electrochemical impedance spectroscopy; Cyclic voltammetry; Current interruption technique, Ex-situ characterization especially electrolyte and bipolar plate	**(06 Hours)**
UNIT - IV	**Fuel Cells Thermodynamics** Gibb's free energy; reversible and irreversible losses; Fuel cell efficiency, Nernst equation, Effect of temperature, pressure, concentration on Nernst potential, Calculations of electrochemical potential.	**(06 Hours)**
UNIT - V	**Fuel Processing** Processing Hydrogen from Alcohols, Producing Hydrogen from Hydrocarbons, Hydrogen from Other Sources, Gas Clean-up, Challenges and Opportunities for Research in Fuel Processing	**(06 Hours)**
UNIT - VI	**Fuel Cell System and system integration** Hydrogen Production, Hydrogen Storage, Methods of Hydrogen Storage, Prediction of Hydrogen Uptake in Carbon Materials, Blance of plant and Power electronic and system integration	**(06 Hours)**

Tutorials/Assignments:

The internal assessment shall consist of minimum SIX assignments.

1.	Questions involving classification of Fuel Cells.
2.	Prepare one assignment considering any one type of fuel cell.
3.	Conducting surprise MCQ test for students
4.	Apply a critical-thinking and problem-solving approach towards the principles of fuel cell.
5.	Enhancement in collaborative learning is done through, group assignments that will be given to encourage students to work with classmates to discuss and complete homework assignments
6.	Students have to study any five research papers related to specific topic and prepare/present power point presentation
7.	Brief report on 'Environmental, health and ethical concerns that are associated with Fuel Cell

	Technology.
8.	Group discussions on any/all of the following topics: d) Classification of Fuel Cells. e) Current scientific and technical advances f) Electrochemical Cell Vs Fuel Cell
9.	Preparation of a brief report on applicability of fuel cells in chemical engineering operations
10.	Write a report on innovations in fuel cell technology in current year.
11.	Learning on performance characteristics of fuel cell power plant and its components.
12.	Identify the operational issues and challenges for all major types of fuel cells and give the presentation on it.
13.	Conducting open-book class test.
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Term Work:	
Term work will consist of the Seminar :	
	Seminar should be based on theory. Students may undertake studies in design and development, analysis, synthesis, construction and fabrication of equipment, treatment plants. Critical review on product and system generation of new concept, idea and improvement in existing process related to subject. Term work should be based on the technical report on these studies carried out by individual or small group of students.
Text Books/ References:	
1.	B. Viswanathan, M. Aulice Scibioh, "Fuel Cells: Principles and Applications", CRC Press, 1 edition, 2008.
2.	James Larminie, Andrew Dicks, "Fuel Cell Systems Explained", 2nd Edition, John Wiley & Sons Ltd, New York, 2003
3.	O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, "Fuel Cell Fundamentals", Wiley, NY, 2006
4.	"Fuel cell: a handbook", U S Department of energy.
5.	Bokris John O'm, Srinivasan S., "Fuel cells-their electrochemistry", McGraw Hill 1969.
6.	Appleby A.J. Fralkes F. R., "Fuel cell handbook", Van Nostrand Reinhold, 1989

7.	Basu, S. (Ed) “Fuel Cell Science and Technology”, Springer, N.Y. 2007
8.	Liu, H., “Principles of fuel cells”, Taylor & Francis, N.Y. 2006
Syllabus for Unit Test:	
Unit Test - I	UNIT– I, II, and III
Unit Test - II	UNIT– IV, V, and VI

Elective III: Membrane Separation			
Designation: Elective			
Course Pre-requisites:			
1.	Basic chemistry, Physical chemistry, Mass transfer, Fluid flow operations, Chemical Engineering Thermodynamics		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3Hours/Week		End Semester Examination: 60 marks	Theory : 03
Term work: 2 Hour/Week		Continuous Assessment: 40 marks	Tutorial : 01
		Term Work: 50 marks	
		Total Marks: 150 marks	
Course Outcomes:			
1.	Explain basics of membrane and select proper material depending upon application		
2.	Explain the methods of membrane preparation and characterization		
3.	Determine suitable process for size based separation and explain its transport mechanism		
4.	Understand the transport through non-porous membranes and define membranes for desired application		
5.	Explain basics and preparation of membrane for other specialized membrane processes		
6.	Design suitable module and parameters for the desired application		
Topics covered			
UNIT-I	**Introduction and Membrane Materials** Introduction, historical development of membrane processes, definition of membrane, permeation, retention and selectivity, membrane processes, their categorization, material for membrane preparation, polymeric material, inorganic materials, mechanical, thermal and chemical stability of membrane based on material, choice of polymer for membrane preparation based on application		**(06 Hours)**

UNIT-II	**Membrane Preparation and Characterizations** Preparation of synthetic membranes: phase inversion membranes, preparation of composite membranes, preparation of inorganic membranes Characterization: Porous membranes – electron microscopy, atomic force microscopy, mercury intrusion, bubble point method, permeability method, solute rejection characteristic; non-porous membranes – permeability, surface analysis, wide angle X-ray, DCS/DTA, density measurement	**(06 Hours)**
UNIT-III	**Processes using porous membranes** Transport mechanism in porous membranes – Knudsen flow, friction model, sieving mechanism Processes: Microfiltration – membranes details, characteristics, industrial applications; Ultrafiltration - membranes details, characteristics, industrial applications; Nano-filtration - membranes details, characteristics, industrial applications.	**(06 Hours)**
UNIT-IV	**Solution-diffusion based membrane processes** Transport mechanism – Solution-diffusion mechanism, solubility, diffusivity, effect of temperature, interaction polymer crystallinity of solubility and diffusivity; Free volume theory Processes: Reverse osmosis - membranes details, characteristics, industrial applications; Gas separation - membranes details, characteristics, industrial applications; Pervaporation - membranes details, characteristics, industrial applications	**(06 Hours)**
UNIT-V	**Other membrane processes** Dialysis - membranes details, their preparation, characteristics, transport mechanism, industrial applications; Electrodialysis - membranes details, their preparation, characteristics, industrial applications; Membrane distillation - membranes details, their preparation, characteristics, industrial applications; Membrane bioreactor - membranes details, their preparation, characteristics, industrial applications; Liquid membranes - membranes details, ionic liquids, their preparation, characteristics, industrial applications; ion exchange - membranes details, their preparation, characteristics, industrial applications	**(06 Hours)**
UNIT-VI	**Membrane modules and process design**	**(06 Hours)**

	Selection of process depending upon applications, plate and frame module, spiral wound module, tubular module, capillary module, hollow fiber module, comparison between module configuration, system design, cross flow operations, hybrid dead end/cross flow operations, cascade operations, Process parameters, Energy requirements	

Term work/Practical:	
1.	Preparation of microfiltration membranes by phase inversion and their transport analysis.
2.	Preparation of UF membranes and their transport analysis
3.	Study of prepared porous membranes for bubble point analysis
4.	Study of porous membranes for rejection analysis
5.	Surface characterization of membrane by instrumental methods
6.	Preparation of asymmetrically skinned membrane and analyze it for pervaporation
7.	Preparation of thin film composite membranes and analyze its transport properties
8.	Preparation of symmetric membrane and analyze its transport and rejection properties
9.	Study variation in fouling characteristics between dead end and cross flow method
10.	Study separation characteristics of reverse osmosis membranes
11.	Preparation of hollow fiber membranes and study its permeation characteristics
12.	Study dialysis /electrodialysis membrane transport characteristics
13.	Study preparation of membrane bio-reactor and its effect of fermentation system
In addition to these above stated term-work concern faculty member may design his/her own term-work or practicals.	
Assignments:	
1.	Detail of membrane material, preparation, characterization, module and process design for anyone application
2.	Technical interview based on knowledge of membrane technology.
3.	Students have to study any five NPTEL/you-tube videos related to membrane technology and prepare/present power point presentation.
4.	Group discussions on membrane science and technology related topics.
5.	Prepare a report on innovations in membrane technology and their practical importance.

6.	Conducting open-book class test.
7.	Conducting surprise Multiple choice questions (MCQs) test for students
8.	Students have to study any five research papers related to specific topic and prepare/present power point presentation
9.	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
10.	Case study on emerging trends in process/product innovation considering membrane technology.
11.	Students have to visit chemical industry and make a detailed report on membrane technologies used in the process.
12.	Write a report on your visit to research and development laboratory of national/international repute.
13.	Write a report on membrane technologies for addressing the problems of Water and Energy.
In addition to these above stated assignments concern faculty member may design his/her own assignments.	
References/Text Books:	
1.	Basic principle of membrane technology Marcel Mulder, Kluwer Academic Press
2.	Membrane technology and applications, Richard W. Baker, John Wiley and Sons, Ltd.
3.	Handbook of industrial membrane technology, Mark C. Porter (Ed.), Noyes Publications.
4.	Membrane separation systems – recent developments and future directions, R. W. Baker, E. L. Cussler, W. Eykamp, W. J. Koros, R. L. Riley, H. Strathman, Noyes Data Corporation
5.	Membrane technology in the chemical industry, S. P. Nunes, K.-V. Peinemann (Eds.), Wiley-VCH Verlag GMBH
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE III: PETROLEUM REFINERY ENGINEERING

Designation: Elective

Course Pre-requisites:

Students should have basic knowledge of

1	Chemical Process Industry
2	Mass Transfer

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
Practical : 2 Hour /Week	Unit Test: 20 Marks	Practical: 01
Total : 5Hours/Week	Continuous Assessment: 20 Marks	Total credits: 04
	Termwork / Oral :50 Marks	
	Total :150 Marks	

Course Outcomes:

After completion of the course students would be able to

1.	Know the composition of crude oil and its products, along with its properties and characterization methods.
2.	Demonstrate knowledge of petroleum products, quality control and understand processing of crude oil.
3.	Understand the thermal and catalytic cracking process.
4.	Learn the process of catalytic reforming, Hydrotreating and Hydrocracking.
5.	Get conversant with the process of purification and fractionation of crude oil.
6.	Analyze theoretical and practice skills in environmental issues of petroleum refinery.

Topics covered

UNIT-I	**Introduction:** Introduction to petroleum refinery, Classification of Crude oil, Characterization of crude oil, Composition of crude Physical properties L6: Crude oil; analysis and distillation, Introduction to refinery "feedstock/s" and refinery products. ASTM nomenclature (ASTM test numbers and their meaning)Introduction to various codes required for petroleum industry	**(06 Hours)**

UNIT-II	**Evaluation of crude oil properties and Design of crude oil distillation column:** Dehydration and desalting of crude. Crude Assay ASTM TBP distillations evaluation of crude oil properties.API gravity various average boiling points and mid percent curves Evaluation of properties of crude oil and its fractions. Design concept of crude oil distillation column design.	**(06 Hours)**
UNIT-III	**Thermal and Catalytic cracking:** Coking and thermal process, delayed coking, Catalytic cracking, cracking reactions, cracking feedstock, Effect of process, FCC cracking, catalyst ,New designs for fluidized bed catalytic cracking	**(06 Hours)**
UNIT-IV	**Catalytic Reforming :** Objective and application of catalytic reforming, process reforming Catalysts, Reformer feed reforming reactor design continuous and semi regenerative process. Hydrotreating and Hydrocracking reactions.	**(06Hours)**
UNIT-V	**Iso merization, Alkylation and Polymerization**: Isomerization process, Reactions, Effects of process variables. Alkylation process, Feedstock, reactions, products, catalysts and effect of process variables. Polymerization: Objectives, process, Reactions, catalysts and effect of process variables. Visbreaking	**(06 Hours)**
UNIT-VI	**Environmental issues and New Trends in petroleum refinery operations:** Ecological consideration in petroleum refinery, Waste water treatment, control of air pollution, New trends in refinery, Alternative energy sources. Safety aspects in petroleum industry	**(06 Hours)**

Assignments	
1.	Write a report on petroleum refining and energy demand in current year.
2.	Discover the methods used to create clean and reformulated fuels
3.	Evaluate the use of catalysts in petroleum refining..
4.	Estimate refinery CAPEX and OPEX
5.	Give power point presentation on vertical integration in petroleum industry
6.	Learning on different areas of study in upstream, midstream and downstream industry.
7.	Analyze worldwide distribution of oil and gas reserves in current year.

8.	Understand basic procedures and role of all fundamental systems used in petroleum drilling..
9.	Apply a critical-thinking and problem-solving approach towards the principles of petroleum engineering.
10.	Specify materials for construction and estimate the cost of investments for crude pil distillation column.
11.	Write a technical report on your visit to a petroleum refinery.
12.	Give power point presentation on knowledge of safety and pollution control in the refining industries.
13.	Group discussion on the recent advances in petroleum refinery processes.
14.	Make a complete chart of operations involved in petroleum industry.
15.	Assess the economic environment of the petroleum industry.
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Term Work:	
Term work will consist of the Seminar :	
	Seminar should be based on theory. Students may undertake studies in design and development, analysis, synthesis, construction and fabrication of equipment, treatment plants. Critical review on product and system generation of new concept, idea and improvement in existing process related to subject. Termwork should be based on the technical report on these studies carried out by individual or small group of students.
Text Books/References:	
1.	B.K.Bhaskar Rao., "Modern Petroleum Refining Processes", 2ndEd., Oxford and IBH publishing Co. Pvt. Ltd., New Delhi 1990.
2.	W.C. Edmister "Applied Hydrocarbon Thermodynamics", Gulf Publishing, Houstan, Texas, 1961.
3.	Gas Production Engineering" S.Kumar Gulf publishing Co., 1987.
4.	Petroleum Exploration Hand Book by Moody, G.B.
5.	standard Handbook of petroleum and Natural Gas Engineering. 2nd Edition. William C Lyons, Gary C Plisga. Gulf Profession.
6.	W.L. Nelson, "Petroleum Refinery Engineering", McGraw Hill, 1964.

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

Elective IV: BIO-SEPARATION		
Designation: Elective		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Basic biology	
2	Analytical chemistry and techniques.	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
Practical : 2 Hour /Week	Unit Test: 20 Marks	Practical: 01
Total : 5Hours/Week	Continuous Assessment: 20 Marks	Total credits: 04
	Term work / Oral :50 Marks	
	Total :150 Marks	

Course Outcomes:

After completion of the course students would be able to

1	Define concept of bio-separation, physico-chemical basis of bio-separation.
2	Explain low resolution bio-separation techniques.
3	Describe high resolution bio-separation techniques.
4	Discuss separation techniques like precipitation, crystallization, etc.
5	Recognize the emerging bio-separation techniques like expanded-bed chromatography, hybrid bio-separations, etc.
6	Apply bio-separation knowledge for purification of β amylase, aspartic acid, etc.

Topics covered

UNIT-I	**INTRODUCTION TO BIOSEPARATION:** An overview of bio-separation, Separation of cells and other insolubles from fermented broth. bioproduct purification, characteristics of biological mixtures, physico-chemical basis of bio-separation.	**(06 Hours)**
UNIT-II	**LOW RESOLUTION BIO-SEPARATION TECHNIQUES:** Cell disruption, Centrifugation, Liquid-liquid extraction, Leaching, Filtration, Supercritical fluid extraction, Micro-filtration, Ultra-filtration, Adsorption,	**(06 Hours)**

	Sedimentation	
UNIT-III	**HIGH RESOLUTION BIO-SEPARATION TECHNIQUES:** Ultra-centrifugation**,** Different electrophoresis techniques viz. Isoelectric focusing, Affinity separation, Chromatographic techniques viz. Paper, Gel; Ion exchange, Affinity, GLC, HPLC. Dialysis.	**(06 Hours)**
UNIT-IV	**OTHER SEPARATION TECHNIQUES:** Zone refining, Molecular sieves, Adductive crystallization, Reactive extraction, Precipitation method using ammonium sulfate, organic solvents, high molecular weight polymers, Reverse osmosis, Foam separation., Aqueous two phase systems,	**(06 Hours)**
UNIT-V	**EMERGING BIO-SEPARATION TECHNIQUES:** Membrane and monolith chromatography, Expanded-bed chromatography, High-resolution ultrafiltration, Hybrid bio-separations, Introduction to SEP box and Hyphenated techniques.	**(06 Hours)**
UNIT-VI	**APPLICATIONS OF BIO-SEPARATIONS -CASE STUDIES:** Purification of β amylase, aspartic acid, insulin; Food and Beverages: Beer, Citric acid; Bio-chemicals: Butanol.	**(06 Hours)**

Assignments:

1.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
2.	Prepare a mini report of any topic given above.
3.	Write a report on the recent advances in chromatographic processes with reference to the current year.
4.	Prepare a model for any of the topic given above.
5.	Evaluate efficiencies of different chromatographic techniques.
6.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
7.	Search out some industries related to bio-separation.
8.	Write a technical report on your visit to a process industry.

9.	Technical interview based on the knowledge of analytical techniques.
10.	List out all the principles of the analytical techniques.
11.	Perform any one chromatographic technique.
12.	Find out different types of proteins with structure.
13.	Prepare a report on downstream processing.
In addition to these above stated assignments concerned faculty member may design his/her own assignments.	
Term Work:	
Term work will consist of the experiments listed below, out of which any eight experiments are to be performed in laboratory by the students.	
1.	Gas chromatography.
2.	Study of membrane separation and its application in industry.
3.	Study of sedimentation and its application in industry.
4	Study of reactive extraction.
5.	Material analysis using paper chromatography
6.	Study of high-resolution ultrafiltration.
7.	Study of gel electrophoresis.
8.	To study molecular sieves.
9.	To estimate efficiency of Centrifugation.
10.	Study of adductive crystallization.
In addition to these above stated experiments concerned faculty member may design his/her own experiments related to course.	
Text Books/References:	
1	Belter P A, Cussler E L, and Wei Shou Hu, "Bio-separation–Downstream Processing for Biotechnology", Wiley India Pvt. Ltd., 2011.
2	Prasad N K, "Downstream Process Technology-A New Horizon in Biotechnology", Prentice Hall of India, New Delhi, 2012.
3	Pauline M Doran "Bioprocess Engineering Principles", Academic Press, London, USA, 2012.
4	B Sivasankar, "Bio-separations: Principles and Techniques", Phi Learning Pvt. Ltd., 2009.

5	Ajay Kumar, Abishek Awasthi “Bio-separation Engineering: Comprehensive DSP Volumen” I.K International Publishing House Pvt. Ltd., New Delhi, 2009.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE IV: ENERGY ENGINEERING

Designation: Elective

Course Pre-requisites:

Students should have basic knowledge of

1	Unit operations, Heat Transfer, Mass Transfer
2	Basic Mathematics and Numerical Techniques.

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
	Unit Test: 20 Marks	
Total : 3Hours/Week	Continuous Assessment: 20 Marks	Total credits: 03
	Total :100 Marks	

Course Outcomes:

After completion of the course students would be able to

1.	Know the basic energy sources *viz* conventional and non conventional.
2.	Evaluate Energy balance and efficiency of any thermal system.
3.	Understand the basic need for pinch analysis and HEN.
4.	Formulate the problem for given energy system.
5.	Model the given energy system and optimize it.
6.	Understand different applications of non conventional energy systems.

Topics covered

UNIT-I	**Basic Energy Sources :** Fossil fuels, Nuclear fuels. Conventional & Renewable Energy Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics. Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, And Nuclear energy etc. Energy Conversion through fission and fusion, Nuclear power generation etc.	**(06Hours)**

UNIT-II	**Energy Management part I:** Importance of energy management. Energy auditing: methodology, analysis of past trends (plant data), closing the energy balance, laws of thermodynamics, measurements, portable and on line instruments. Steam Systems: Boiler -efficiency testing, excess air control, Steam distribution & use- steam traps, condensate recovery, flash steam utilization. Thermal Insulation.	**(06 Hours)**
UNIT-III	**Energy Management part II** Energy conservation in Pumps, Fans (flow control), Compressed Air Systems, Refrigeration& air conditioning systems. Heatexchanger networking- concept of pinch, target setting, problem table approach, composite curves.	**(06 Hours)**
UNIT-IV	**Energy Systems Analysis:** Case studies of optimization in Energy systems problems. Dealing with uncertainty- probabilistic techniques. Trade-offs between capital & energy using Pinch Analysis. Case studies	**(06 Hours)**
UNIT-V	**Application of Non-conventional energy systems in Industry**: Solar energy Applications, Wave Energy and Ocean Thermal Energy, Wind Energy, Biomass Energy, Energy from Waste.	**(06 Hours)**
UNIT-VI	**Economic Analysis**: Initial and annual cost, basic definitions, present worth calculations, economic analysis of add on solar system, Energy audit	**(06 Hours)**

Assignments	
1.	Write a report on the recent advances in Energy Efficiency.
2.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
3.	Compare the industrial data for energy utilization used in 5 different industries.
4.	Write a report on your heat transfer equipments to minimize energy loss.
5.	Present a seminar on Pinch Technology and HEN.
6.	Present a seminar on thermal equipments involved in industry.
7.	Prepare a model on non conventional energy sources and applications.
8.	Write a energy audit for any single industry.

Text Books/References:

1.	J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.

2.	D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000
3.	L.C.Witte, P.S.Schmidt, D.R.Brown , Industrial Energy Management and Utilisation, Hemisphere Publ, Washington,1988.
4.	I.G.C.Dryden, Butterworths, The Efficient Use of Energy, London, 1982
5.	Freris L.L., Wind Energy Conversion Systems, Prentice Hall 1990.
6.	S.S.RaoOptimisation theory and applications, Wiley Eastern, 1990
7.	Beveridge and Schechter,Optimisation Theory and Practice,Mcgraw Hill, 1970
8.	Shenoy U. V., Heat Exchanger Network Synthesis: Processes Optimization by Energy
9.	Fowler, J.M., Energy and the environment, 2nd Edn., McGraw Hill, New York, 1984

Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE - IV: GREEN TECHNOLOGY					
Designation: Elective					
Course Pre-requisites:					
Students should have basic knowledge of chemistry and pollution control.					
TEACHING SCHEME:		**EXAMINATION SCHEME:**		**CREDITS ALLOTTED:**	
Lectures	: 3 Hours/Week	End Semester Examination	: 60 Marks	Theory	: 03
Practical	: 2 Hour /Week	Unit Test	: 20 Marks	Practical	: 01
Total	: 5 Hours/Week	Continuous Assessment	: 20 Marks	Total credits	: 04
		Term Work/Oral	: 50 Marks		
		Total	: 150Marks		

Course Outcomes:

After completion of the course students will be able to:

1.	Identify the major environmental issues and describe the need for green technology.
2.	Explain green technology principles and protocols.
3.	Identify and explain the green synthetic methods.
4.	Explain biochemical conversion and bio-photolysis.
5.	Explain criteria for choosing appropriate green energy technologies, Green innovation & sustainability.
6.	Explain the green house effects, global warming, carbon footprint and ways to overcome them using green technology.

Topics covered

UNIT - I	**Introduction and need for green technology:** Overview of Major Environmental Issues, Global Environmental Issues. Air Quality Issues. Water Quality Issues, Ecology, Natural Resources, Waste: Production, Prevention, Problems and Source of waste, cost of Waste, Waste minimization technique, waste treatment and recycling. Description of Risk. Value of Risk Assessment in the Engineering Profession. Risk-Based Environmental Law. Risk Assessment Concepts. Hazard Assessment, Risk Characterization. Role of Industry, Government and Institutions in green	**(06 Hours)**

	technology.	
UNIT - II	**Green technology principals and protocols:** Importance, advantages and disadvantages of green technologies, factors affecting green technologies, the twelve basic principles of green chemistry. Sustainable development, atom economy, reduction of toxicity. Use of Renewable Feedstock, Reduction of Derivatives, Catalysis, Design for Degradation, Real-time Analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention.	**(06 Hours)**
UNIT - III	**Green synthetic methods:** Microwave synthesis, electro-organic synthesis, Design and development of environmentally friendly chemical pathways: challenges and opportunities. Materials for green chemistry and technology: Catalysis, environmental friendly catalysts, Bio-catalysis, biodegradable polymers, alternative solvents,	**(06 Hours)**
UNIT - IV	**Biochemical conversion:** Anaerobic digestion, alcohol production from biomass; Chemical conversion process: hydrolysis and hydrogenation; Biophotolysis: Hydrogen generation from algae biological pathways; Storage and transportation; Applications	**(06 Hours)**
UNIT - V	**Green innovation & sustainability:** Criteria for choosing appropriate green energy technologies, life cycle cost; the emerging trends – process/product innovation, Eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity- WEHAB (eco-restoration/ phyto-remediation, ecological sanitation, renewable energy technologies).	**(06 Hours)**
UNIT - VI	**Green house effect and Global warming:** Greenhouse gas emissions, impacts, mitigation and adaptation, carbon credit, carbon footprint ; future energy Systems- clean/green energy technologies; International agreements/conventions on energy and sustainability - United Nations Framework Convention on Climate Change (UNFCC), Kyoto protocol; sustainable development, Environmental reporting and ISO 14001; climate change business and ISO 14064; green financing; financial initiative by UNEP	**(06 Hours)**

Term Work:	
Term work will consist of the seminars on the following topics.	
1	Major Environmental Issues and need for green technology
2	Green technology principals and protocols
3	Green synthetic methods
4	Biochemical conversion and Biophotolysis
5	Green innovation & sustainability
6	Green house effect and Global warming
Assignments:	
1.	Technical interview based on knowledge of green technology.
2.	Students have to study any five NPTEL videos related to green technology and prepare/present power point presentation.
3.	Group discussions on any one of the following topics.
	a) Major Environmental Issues.
	b) Green innovation & sustainability.
	c) Global warming
4	Prepare a report on innovations in green technology and their practical importance.
5	Conducting open-book class test.
6	Conducting surprise Multiple choice questions (MCQs) test for students
7	Students have to study any five research papers related to specific topic and prepare/present power point presentation
8	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
9	Case study on emerging trends in process/product innovation considering green technology.
10	Students have to visit chemical industry and make a detailed report on green technologies used in the process.
11	Write a report on your visit to research and development laboratory of national/international repute.
12	Write a report on eco/green technologies for addressing the problems of Water and Energy.
13	Write a report on eco/green technologies for addressing the problems of Water, Energy, Health, Agriculture and Biodiversity (WEHAB).

In addition to these above stated assignments concern faculty member may design his/her own assignments.	
Text Books/ References:	
1	Paul Anastas, John C.Warner, John Warner Joint; Green Chemistry: Theory & Practice New Edition; Oxford University press, USA, 2000.
2	Mukesh Doble and Anil Kumar Kruthiventi, Green Chemistry and Engineering, Elsevier, Burlington, USA, 2007.
3	Allen, D.T., Shonnard, D.R, Green Engineering: Environmentally Conscious Design of Chemical Processes. Prentice Hall PTR 2002.
4	Baird, C. and Cann, M., Environmental Chemistry, 4th Edition, W.H. Freeman and Company, New York, 2008.
5	Paul T. Anastas, Walter Leitner, Phillip G. Jessop, Chao-Jan Li, Peter Wasserscheid, Annegret Stark; Handbook of Green Chemistry, 3 Volume set, Green solvents; Wiley-VCH.
6	Paul T. Anastas, Istvan T. Horvath ; Green Chemistry for a sustainable future; Wiley-Blackwell publishers, 2010.
7	V.K. Ahluwalia, M. Kidwai; New Trends in Green Chemistry; Kluwer Academic Publishers.
Syllabus for Unit Test:	
Unit Test - I	UNIT– I, II, III
Unit Test - II	UNIT– IV, V, VI