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

Sr. No.	Subject	Teaching Scheme (Hours/week)			Examination Scheme (Marks)							Credit		
		L	P/D	T	End Semester Examination	Continuous Assessment			TW/O	TW/P	Total	Theory	P/D	Total
						Unit Test	Attendance	Assignments						
1	Elective-I	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
2	Mass Transfer Operation	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
3	Chemical Reaction Engineering- I	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
4	Chemical Engineering Mathematics	3	-	1	60	20	10	10	50	-	**150**	4	-	**4**
5	Computer Programming for Chemical Engineers –I	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
6	Professional Skill Development-V	4	-	-	100	-	-	-	-	-	**100**	4	-	**4**
Total		**21**	**6**	**1**	**400**	**100**	**50**	**50**	**50**	**150**	**800**	22	3	**25**

Bharati Vidyapeeth University
Faculty of Engineering and Technology
Programme: B. Tech. (Chemical) - Semester VI - 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
7	Elective-II	3	-	-	60	20	10	10	-	-	**100**	3	-	**3**
8	Separation Techniques	4	2	-	60	20	10	10	-	50	**150**	4	1	**5**
9	Chemical Process Equipment Design– I	3	2	-	60	20	10	10	-	25	**125**	3	1	**4**
10	Chemical Reaction Engineering – II	3	2	-	60	20	10	10	-	50	**150**	3	1	**4**
11	Process Instrumentation and Instrumental Methods of Analysis	3	2	-	60	20	10	10	-	25	**125**	3	1	**4**
12	Professional Skill Development-VI	4	-	-	100	-	-	-	-	-	**100**	4	-	**4**
13	Computer Programming For Chemical Engineering-II	-	2	-	-	-	-	-	-	50	**50**	-	1	**1**
Total		**20**	**10**	**-**	**400**	**100**	**50**	**50**	**-**	**200**	**800**	20	5	**25**

Total Credits
Semester V : 25
Semester VI : 25
Grand Total : 50

Elective I: Advanced Material Science		
Designation: Elective		
Course Pre-requisites:		
1.	Basic chemistry, Basic physics, Chemical Engineering Materials, Physical chemistry, Chemical Reaction Engineering, Chemical Engineering Thermodynamics	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 marks	Theory : 03
	Continuous Assessment: 40 marks	

Course Outcomes:	
1.	Explain basics of polymers and their classifications
2.	Explain various polymer properties and the their effect on engineering properties
3.	Determine suitable process for polymer synthesis and describe its mechanism
4.	Understand the basics of polymer characterizations and discuss its effect on properties
5.	Explain the formation of composites and blends in polymers
6.	Explain the methods of polymer compounding and processing

Topics covered		
UNIT-I	**Material composites** Introduction to composite materials, factors influencing the properties of composite materials like fiber parameter, matrix, interface & molding methods. Phase selection criteria. Reinforcing mechanisms. Interfaces, advantages and disadvantages. Polymer composites. Reinforcing and matrix materials, prepregs, fiber winding techniques, fabrication techniques, laminates, mechanical behavior, etc.	**(06 Hours)**
UNIT-II	**Composite and reinforcement** Metal composites, types of reinforcement, chemical compatibility, fabrication processes, mechanical behavior and properties, ceramic composites. Matrices and reinforcement. Why to reinforce ceramics, fabrication methods, crack propagation and mechanical behavior.	**(06 Hours)**
UNIT-III	**Carbon composites** Carbon composites, their properties, fabrication methods and their applications, ablative polymers, their applications, air craft materials, introduction to nonmaterial, synthesis & characterization of nonmaterial, application of nonmaterial with special reference to chemical engineering.	**(06 Hours)**
UNIT-IV	**Nuclear materials** Atomic structure, atomic number, mass number, isotopes, nuclear energy and nuclear forces, binding energy, nuclear stability, radioactivity, nuclear reactions, nuclear fissions, nuclear fusion, Types of waste –disposal – radiation hazards and prevention	**(06 Hours)**
UNIT-V	**Biomaterials**	**(06**

	Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials and their application to processing. Novel Biomaterials and Uses in Engineering and Tissue Engineering: Hydrogels, self-assembling peptides, Implants materials: Metallic implant materials, hydroxyapatite glass ceramics carbons, Polymeric implant, medical applications.	**Hours)**
UNIT-VI	**Nanomaterials** Basics - distinction between molecules, nanoparticles and bulk materials; size-dependent properties. Nanoparticles: nano cluster, nano rod, nanotube (CNT) and nanowire. Synthesis: precipitation, thermolysis, hydrothermal, solvothermal, electrode position, chemical vapour deposition, laser ablation; Properties and applications	**(06 Hours)**

Assignments:

1.	Prepare the report on any advanced material comprising its significance, preparation, characterization, processing, properties and application

References/Text Books:

1.	L.C. Merrite, "Basic principles of Nuclear science and Reactors" Wiley Eastern 1977.
2.	Polymers of high technology, electronics and photonics, Bowden M.J & Turner S.R., ACS Symp. Ser. 346, 1987.
3.	Composite Materials , Chawala K.K., Springer Science & Business Media.
4.	Buddy D. Ratner Allan S. HoffmanFrederick J. SchoenJack E. Lemons Biomaterials Science, Second Edition: Wiley Science 2004.
5.	"An Introduction to Materials Engineering and Science for Chemical and Materials Engineers," by Brian S. Mitchell; Wiley-Interscience, 2003; ISBN 0471436232.
6.	Carl C. Koch (ed.), "Nanostructured Materials", Processing, Properties and Potential Applications, Noyes Publications, Norwich, New York, U.S.A.
7.	Bhusan, Bharat (Ed), “Springer Handbook of Nanotechnology”, 2nd Edition, 2007.

Syllabus for Unit Test:

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

ELECTIVE I COMBUSTION ENGINEERING

Designation: Elective

Course Pre-requisites:

Students should have

1.	Basic knowledge of chemistry

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3Hours/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 fundamental definitions, properties and various measurement techniques for fuels.
2.	Describe the combustion techniques of solid fuel i.e. coal.
3.	Explain the concept of exploration of crude petroleum and refinery equipments.
4.	Explain about different important gaseous fuels
5.	Emphasis is given to combustion of various fuels in the light of thermodynamics and applies the knowledge of gross and net calorific values of fuel and solves the problems based on them.
6.	Describe the incineration technology.

Topics covered

UNIT-I	**Introduction:** History of Fuels : History of solid fuel, History of liquid fuels and gaseous fuels, Production, present scenario and consumption pattern of fuels, Fundamental definitions, properties and various measurements: Definitions and properties of solid fuels, Definitions and properties of liquid and gaseous fuels, Various measurement techniques.	**(06 Hours)**
UNIT-II	**Solid Fossil Fuel (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 liquefaction, Indirect liquefaction), Coal gasification	**(06 Hours)**
UNIT-III	**Liquid Fossil Fuel (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.	**(06 Hours)**
UNIT-IV	**Gaseous Fuels:** Natural gas and LPG, Producer gas, Water gas, Hydrogen, Acetylene, Other fuel gases	**(06 Hours)**
UNIT-V	**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	**(06 Hours)**
UNIT-VI	**Incineration Technology:** Classification, Key Issues, Pretreatment of Waste, Sorting, Homogenization, Moving Grate Incineration, Rotary Kiln Incineration, Fluidized Bed Incineration, advantages, disadvantages and applications of incineration. Furnaces and Boilers.	**(06 Hours)**

Assignment:	
1.	Presentations on any topic of combustion engineering.
2.	Recent trends in combustion technology.
3.	Alternative fuel for engines.
4.	Measurement of calorific values of any two types of fuel.
5.	Detail study on solid fossil fuel.
6.	Solve last five years GATE question papers with reference to combustion engineering.
7.	Students have to study any five NPTEL videos related to combustion engineering and prepare/present power point presentation.
8.	Numerical based on above fifth unit.
9.	Detail study on liquid fossil fuel.
10	Detail study on gaseous fuels.
11.	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
12.	Prepare a report on combustion technology which is newly introduced in the current year.
13.	Write a report on incineration technology.
In addition to these above stated assignments concern faculty member may design his/her won.	
Text Books/References:	
1.	Richard A. Dave, "Modern Petroleum Technology", Vol 1 , Upstream, 6th ed., John Wiley & Sons. Ltd.2002.
2.	Alan G. Lucas, "Modern Petroleum Technology", Vol 2, Downstream, 6th ed., John Wiley & Sons. Ltd.2002.
3.	Irvin Glassman, "Combustion", 2nd ed., Academic Press.2009.
4.	B.K. Bhaskar Rao, "Modern Petroleum Refining Processes", 5th ed., Oxford & IBH Publishing Co. Pvt. Ltd.2007.
5.	John Griswold ,"Fuels Combustion and Furnaces" , Mc-Graw Hill Book Company Inc.1988.
6.	Samir Sarkar, "Fuels and Combustion", 3rd. ed Universities Press.2009.
7.	W.L. Nelson, "Petroleum Refinery Engineering", 4th ed. Mc-Graw Hill Book Company.1958.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

ELECTIVE-I : MULTIPHASE FLOW		
Designation: Elective		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Fluid Flow Operations	
2	Process Heat Transfer	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 3 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
	Continuous Assessment : 40 Marks	Total credits : 03
	Total : 100 Marks	
Course Outcomes:		
After completion of the course students will be able to		
1.	Explain the concept of two phase flow and describe the flow types, flow regimes in horizontal and vertical flow	
2.	Describe the two phase flow classifications.	
3.	Explain the mixing power correlations.	
4.	Identify and explain packed bed, fluidized bed, bubble column and its design aspects.	
5.	Explain the concept of multiphase flow and identify the flow regimes.	
6.	Explain cavitation and RTD in multiphase flow system.	

Topics covered		
UNIT-I	**Gas/liquid and liquid/liquid Two phase flow:** Scope and significance of multiphase flows, Dimensionless numbers in multiphase flows; Flow types and regimes in horizontal and vertical flow, Regime maps, Behaviour of non-Newtonian fluids in two phase flow.	**(06 Hours)**
UNIT-II	**Flow Classification:** Two-phase Co-current flow of Gas-Liquid, Gas-Solid and Liquid-Liquid, Upward and Downward Flow in Vertical pipes. Suspensions of Solid and their transport in Horizontal Pipes. Drag Reduction Phenomena, Laminar, Turbulent and Creeping Flow Regimes.	**(06 Hours)**
UNIT-III	**Mixing Power Correlations:** Theories of Intensity and Scale of Turbulence. Calculation of Circulation Velocities and Power Consumption in Agitated Vessels for Newtonian and Non-Newtonian Fluids. Blending and Mixing of Phases, flow patterns. Power requires for aeration to suspend to an Immiscible Liquid or Solids in Slurry Reactors, Prediction of optimum speed of Impeller Rotor. Mixing equipments.	**(06 Hours)**
UNIT-IV	**Quantification of Flow System:** Prediction of Holdup, Pressure Drop and bubble size in pipe flow, Lockhart – Martinelli Parameters, Bubble Column and its Design aspects; Flow through Packed Bed and Fluidized Bed, Minimum Carryover Velocity. Holdup Ratios, Pressure Drop and Transport Velocities and their prediction. Solid-Fluid Conveying and Settling.	**(06 Hours)**
UNIT-V	**Flow in Three - Phase Systems:**	**(06 Hours)**

	Introduction to three phase flow; Flow regime identification, pressure drop, void fraction and flow rate measurement, Prediction of Holdup, Pressure Drop and throughput velocities in three –phase system. phase separation and settling behaviour, analysis of stratified and bubble flow, formation of bubbles and drops and their size distribution and hold up in different flow system, momentum and energy relations.	
UNIT-VI	**RTD in multiphase flow system:** Non-Ideal Flow: Residence time distribution of fluid in vessel, non-ideal flow patterns, E, F, C curve, Mean and variance, residence time, Models for non-ideal flow. **Cavitation:** Introduction, types of cavitation, mechanism of cavitation. Key features of bubble cavitation: cavitation inception, cavitation bubble collapse, shape distortion during bubble collapse, cavitation damage. Cavitation bubbles: observations of cavitating bubbles, cavitation noise and cavitation luminescence.	**(06 Hours)**

Assignments	
1	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
2	Students have to study any five NPTEL videos related to multiphase flow and prepare/present power point presentation.
3	Students have to visit chemical industry and make a detailed report on multiphase flow.
4	Write a report on the recent advances in multiphase flow with reference to the current year.
5	Prepare models for bubble column, packed bed and fluidized bed reactors.
6	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
7	Write a report on your visit to research and development laboratory of national/international repute.
8	Solve old (last five years) GATE question papers with reference to multiphase flow.
9	Group discussions on any one topic from above six units.
10	Technical interview based on the knowledge of multiphase flow.
In addition to these above stated assignments concerned faculty member may design his/her own assignments	

Text Books/References:

1.	Wallis, G.B.; One Dimensional Two Phase Flow, McGraw Hill Book Co., New York, 1969.
2.	Hewitt, G.F.; Measurement of Two Phase Flow Parameters.
3.	Govier, G. W. and Aziz, K.; The Flow of Complex Mixture in Pipes, Richardson, Tex.: Society of Petroleum Engineers 2008.
4.	Butterworth and Hewitt, Two Phase Flow
5.	John, G. Collier and John, R.Thome,; Convective Boiling and Condensation, Oxford University Press, 3rd Edition, 2002.
6.	Levenspiel, O.; Chemical Reaction Engineering, 3rd Ed , John Wiley & Sons, Singapore (1999).
7.	Doraiswamy, L.K., and Sharma, M.M.; Heterogeneous Reactions: Volume 2 Fluid-Fluid-Solid Reaction, John Wiley & Sons, 1984, Singapore
8.	Coulson, J.M. and Richardson, J.F.; Chemical Engineering, Vol I, 6th edition, Oxford, 1999.
9.	D.G. Knudsan and D. L. Katz. Fluid Dynamics and Heat transfer. Mc-Graw Hill, 1958
10.	A.H. P. Skelland “Non Newtonian flow and Heat transfer” John Wiley 1867

11.	Brodkey, R. S.; The Phenomena of Fluid Motions", Addision –Weseley, New York, 1967.
12.	Hestroni, G., (Ed.) ; Hand book of Multiphase systems, Hemisphere Publishing, Washington, 1982.
13.	Christopher, E. Brenner,; Fundamentals of multiphase flows, Cambridge University Press 2005.

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

Elective I Rheology		
Designation: Elective		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week	End Semester Examination: 60 Marks	Theory : 03
Practical : ---	Unit Test: 20 Marks	Practical: ---
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.	Apply the rheological models to study the rheology of non-Newtonian fluids
2.	Describe the operation of instruments used for measurements of rheological properties
3.	Obtain the rheological behavior of non-Newtonian fluids
4.	Explain the rheological models for rubber compounds
5.	Describe the models to represent behavior of polymer liquids
6.	Obtain the variable influencing the rheology of fluids

Topics covered		
UNIT-I	**Introduction** Types of fluid flow, time dependant fluids, shear rate dependant fluids, Newtonian and Non Newtonian fluids, Definition of Rheology, Rheological Perspective, The importance of nonlinearity, Solids and liquids, Components of rheological research: Rheometry, Constitutive equations.	**(08 Hours)**
UNIT-II	**Rheological Models** Power law fluid Model, Eyring Model, Bingham Plastic fluid model, Ellis fluid model, Eyring-Powel model , Reiner-Phillipoff model , Meter model. **Instruments used for measurements of Rheological properties** capillary rheometer, melt flow index, cone and plate viscometer, Torque rheometer, Mooney viscometer	**(08 Hours)**
UNIT-III	**Experimental Studies of Rheological Behavior :** Steady Shear Flow: Elongation Flow, Oscillating Flow: Stress Relaxation, Temperature Dependence: Processability, Test & Dependence upon Polymer Structure, Shear Flow Boundary Conditions and Slippage, Flow induced Degradation & Mechanochemistry.	**(08 Hours)**
UNIT-IV	**Rheology of Rubber** Rheological Models and Approaches to Flow Analysis: One Dimensional Rheological Models for Rubber Compounds: Plastic Viscous Model, Plastic Viscoelastic Model, Thixotropic Model, Equation of Motion and Dimensional Analysis of Non-Newtonian Fluids: General, Viscoelastic Fluids, Plastic Fluids, Energy Equation & Non Isothermal Flow :Energy Equation, Dimensional Analysis, Classification of Flows :Internal & External Flow, Hydrodynamic Lubrication Theory.	**(08 Hours)**
UNIT-V	**Rheology of polymers** **Introduction**	**(08 Hours)**

	Elastic materials ,Viscous materials, Viscoelasticity, Effect of rate of strain, temperature and time on mechanical behavior of polymeric materials, creep, stress relaxation **Models to represent behavior of Polymer Liquids** Mechanical models, stress strain response of spring and dashpot Viscoelastic models, Maxwell element, Voigt Oelvin element, response to creep and stress relaxation, Four parameter model, dynamic mechanical properties, behavior of Maxwell element and relaxation spectra	
UNIT-VI	**Variable influencing the Rheology of fluids** Effect of Temperature, Effect of Pressure, Effect of Molecular weight & Molecular structure, effect of entanglement of molecules & molecular motions.	**(08 Hours)**

Assignments	
1.	Group discussion on the recent advances in rheology.
2.	Presentation on a instruments used for measurements of rheological properties.
3.	Group discussion on importance of studying this elective.
4.	Technical interview based on the knowledge of rheology.
5.	Presentation on rheological models for rubber compounds.
6.	Write a report on your visit to research and development laboratory of national/international repute.
7.	Technical interview based on the knowledge of rheology.
8.	Preparation of report on recent trends in rheology of polymers.
9.	Group discussion on variable influencing the rheology of fluids

In addition to these above stated assignments concerned faculty member may design his/her own assignments

Text Books/References:	
1.	R. B. Bird, W. E. Stewart, E. N. Lightfoot, " Transport Phenomena" Wiley- India, New Delhi
2.	Dr. B. R.Gupta, "Rheology of Elastomers"
3.	H.A. Barnes, J. F. Hutton and K. Walters, "An Introduction to Rheology"
4.	R. P. Chhabra & J. F. Richardson , "Non-Newtonian Flow and Applied Rheology"
5.	Chang Dae Han, "Rheology in Polymer Processing", Academic Press, New York
6.	R.S. Lenk, "Polymer Rheology", Applied Science, London

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

MASS TRANSFER OPERATION		
Designation: Professional Core		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Heat Transfer operation	
2	Unit Operations and stiochiometry	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 4 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 2 Hour /Week	Unit Test : 20 Marks	Practical : 01
Total : 6Hours/Week	Continuous Assessment : 20 Marks	Total credits : 05
	Term work / practical : 50 Marks	
	Total : 150 Marks	
Course Outcomes:		
After completion of the course students would be able to		
1.	Evaluate diffusivity and rate of diffusion.	
2.	Evaluate mass transfer coefficients and understand interphase mass transfer.	
3.	Calculate the height of transfer unit, number of transfer unit, in absorption column.	
4.	Calculate rate of mass transfer in humidification.	
5.	Estimate rate and time of drying.	
6.	Analyze type of crystallization and estimate yield of crystallization.	
Topics covered		
UNIT-I	**Diffusion** Molecular diffusion in fluids: Steady state diffusion in fluids at rest and in laminar flow, Steady state diffusion of A through nondiffusing B , equimolal counter diffusion, steady state diffusion in multicomponent mixture , molecular diffusion in fluids, diffusivity of liquids and gases, effect of temperature and pressure on diffusivity, diffusion in solids. Laws of diffusion and empirical equations – Maxwell's law, Stefan's law, Winkle man's method.	**(08 Hours)**
UNIT-II	**Mass transfer Coefficient and Interphase Mass Transfer:** a) **Mass transfer coefficients:** Mass transfer coefficient in laminar flow and in turbulent flow. Relation of individual and overall mass transfer coefficient. Theories of mass transfer. Mass, heat and momentum transfer analogies. b) **Interphase mass transfer**. Equilibrium in mass transfer, two resistance concept. diffusion between phases. Steady state co-current and counter current processes. continuous crosscurrent, counter-current, crosscurrent cascade operations and mass balances.	**(08 Hours)**
UNIT-III	**Absorption:** Introduction to absorption, types of tower packing's, contact between liquid and gas, pressure drop and limiting flow rates, material balances for each flow , limiting gas-liquid ratio, rate of absorption, calculation of HTU, NTU and	**(08 Hours)**

	HETP. Alternate forms of transfer coefficients and their relations. Tray Efficiencies, absorption in plate columns, absorption with chemical reaction. Equipments for absorption column.	
UNIT-IV	**Humidification:** Vapor-liquid equilibrium, enthalpy for pure substances, definitions of humidity terms, adiabatic saturation temperature, wet bulb and dry bulb temperatures, study of humidity charts, lewis relation. method of adiabatic humidification and dehumidification. Equipments for humidification, cooling tower design.	**(08 Hours)**
UNIT-V	**Drying:** Basic principles of drying. equilibrium in drying. definitions of terms in drying, types of moisture binding, rate of drying curve, mechanism of batch drying and continuous drying, time requirement for drying, mechanism of moisture movement in solids. Equipments used for drying: Classification of dryers, solids handling in dryers, equipments for batch and continuous drying processes: working principle of tray driers, tower driers, rotary driers, spray driers. Concept of freeze drying	**(08 Hours)**
UNIT-VI	**Crystallisation:** Introduction to the process, principal rate of crystallization, Mier's supersaturation theory, growth and properties of crystals, crystallisation rate, calculations of yield, mass and enthalpy balances. Equipments used in crystallization.	**(08 Hours)**

Assignments

1.	Write a report on the recent advances in mass transfer processes with reference to the current year.
2.	Solve old (last five years) question papers with reference to particular topic.
3.	Prepare a model for any of the Mass transfer equipment.
4.	Prepare a report on Mass transfer equipments which are newly introduced in the current year.
5.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
6.	Evaluate efficiencies of different Gas-liquid contact equipment. .
7.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
8.	Design laboratory manuals better than existing ones with clearly shown specimen calculations.
9.	Compare working and principles for different mass transfer operations.
10.	Solve numerical for any industrial data.
11.	Write a technical report on your visit to a process industry.
12.	Solve old (last ten years) GATE question papers with reference to Mass transfer-I subject.
13.	Group discussion on the recent advances in mass Transfer equipments.
14.	Write a report on your visit to research and development laboratory of national/international repute.
15.	Technical interview based on the knowledge of Mass transfer.

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.	To calculate diffusion coefficient in Liquid-Liquid diffusion.
2.	To calculate diffusion coefficient in still air..
3.	To study characteristics of Wetted Wall Column.
4	To calculate individual and overall interface mass transfer coefficient.
5.	To estimate efficiency of cooling Tower.
6.	To estimate rate of drying in tray drier/rotary drier
7.	To study the crystallization process by air, water cooling and seeding.
8.	Humidification and Dehumidification experiment.
9.	To study agitated batch crystallizer
10.	Study of Spray drier
Text Books/References:	
1.	McCabe, W. L., J. Smith, and Harriot: "Unit operations of chemical engineering," Tata McGraw Hill.
2.	Treybal R.E., Mass Transfer Operations, 3rd Ed., McGrawHill, 1981.
3.	King C. J. "Separation Techniques," McGraw Hill Publications
4.	Richardson, J. F., and J. M. Coulson: "Chemical Engineering," Butterworth Heinemann, Volume 1.
5.	E. L. Cussler, "Diffusion Mass Transfer in fluid systems " 3rd Ed. Cambridge Series in Chemical Engineering.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL REACTION ENGINEERING-I			
Designation: Professional Core			
Course Pre-requisites:			
Students should have basic knowledge of			
1	Analytical and physical Chemistry		
2	Process Calculation		
3	Mathematics including integration and derivation		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 4 Hours/Week		End Semester Examination: 60 Marks	Theory : 04
Practical : 2 Hour /Week		Unit Test: 20 Marks	Practical: 01
Total : 6Hours/Week		Continuous Assessment: 20 Marks	Total credits: 05
		Termwork / practical:50 Marks	
		Total :150 Marks	
Course Outcomes:			
After completion of the course students would be able to			
1.	Define rates of homogeneous chemical reactions and express the temperature dependent term of a rate equation with Arrhenius' Law and other theories		
2.	Design experiments, analyze and interpret data, and apply the results to chemical systems and processes.		
3.	Design ideal batch reactors, ideal CSTR reactors and ideal plug flow reactors.		
4.	Analyze multiple reactor system, autocatalytic and recycle reactors.		
5.	Specify operating conditions to produce desired products from parallel and series chemical reactions.		
6.	Evaluate effect of temperature on reaction.		
Topics covered			
UNIT-I	**Chemical Kinetics:** Classification of reactions, rate laws and stoichiometry, relative rates of reaction, reaction order, rate limiting step, half life, concentration-dependent term of a rate equation, temperature-dependent term of a rate equation, Temperature dependency from Arrhenius law, Transition state theory, collision theory, rate equation using partial pressure and concentration, their interrelation, searching for a reaction mechanism.		**(08 Hours)**
UNIT-II	**Interpretation of Batch reactor data:** Interpretation of batch experimental kinetics data using integral and differential analysis, constant volume batch reactor system, design equation for zero, first, second and third order irreversible and reversible reactions, graphical interpretation of these equations and their limitations, variable volume batch reactors, design equation for zero, first and second order irreversible and reversible reactions, graphical interpretation of their limitations.		**(08 Hours)**
UNIT-III	**Introduction to Reactor Design** Single ideal reactors under steady state conditions, design equations for batch,		**(08 Hours)**

	mixed flow & plug flow reactor, development of rate expression for mean holding time for a plug flow reactor, space time and space velocity, Introduction to Semi-batch reactor.	
UNIT-IV	**Isothermal flow reactors** Size comparison of reactor performance, sequences of reactors, reactors with recycle. optimum size determination, reactors in series and parallel, performance of infinite number of back mix reactors in series, back mix and plug flow reactors of different sizes in series and their optimum way of staging, optimum recycle ratio for auto –catalytic (recycle) reactors.	**(08 Hours)**
UNIT-V	**Design of reactors for Single and Multiple reactions** Parallel and consecutive reactions in batch, CSTR and PFR, qualitative discussion about product distribution, quantitative treatment of product distribution and reactor size, factors affecting such as choice, optimum yield, conversion, selectivity, reactivity on consecutive and parallel reactions in reactors.	**(08 Hours)**
UNIT-VI	**Non-Isothermal reactor for homogeneous reactor systems** Energy balances in reactors, adiabatic operations, non-adiabatic operations, stability of reactors, non-isothermal homogeneous reactor systems, rates of heat exchanges for different reactors, adiabatic operations for batch and continuous reactors, optimum temperature progression, rate, temperature and conversion profiles for exothermic and endothermic reactions.	**(08 Hours)**

Assignments	
1.	Write a report on the recent advances in chemical reaction engineering with reference to the current year.
2.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
3.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
4.	Derive the rate equations for various combinations of reactors.
5.	Suggest best suitable reactor arrangement for zero, first and second order reaction.
6.	Explain in detail use of kinetics in equipment/reactor design.
7.	Design laboratory manuals better than existing ones with clearly shown specimen calculations.
8.	Solve old (last five years) question papers with reference to particular topic.
9.	Prepare a model for any of the reactor.
10.	Solve old (last ten years) GATE question papers with reference to chemical reaction engineering subject.
11.	Group discussion on the recent advances in reaction engineering.
12.	Write a report on your visit to research and development laboratory of national/international repute.
13.	Technical interview based on the knowledge of chemical reaction engineering.
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.	Study of first order reaction.
2.	Study of PFR & CSTR combination in second order reaction.

3.	Rate constant of hydrolysis of methyl acetate by dilute HCl.
4	Energy of activation of a reaction between $K_2S_2O_8$ and KI
5.	Study of homogeneous catalytic reaction, decomposition of hydrogen peroxide, acid catalysed ester hydrolysis.
6.	Hydrolysis of ester (e.g. ethyl acetate) by alkali (NaOH).
7.	Study of CSTR combination in first order reactions.
8.	Determination of Arrhenius parameters.
9.	Rate constant for saponification of ethyl acetate with NaOH using CSTR.
10.	Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using PFR.
11.	Rate constant for saponification of ethyl acetate with NaOH at ambient conditions using (i) Isothermal batch reactor (ii) Isothermal CSTR.
12.	Study and operation of an adiabatic batch reactor.
13.	Study of a reversible reaction in a batch reactor.
14.	To determine energy of activation of reaction of ethyl acetate with sodium hydroxide.
15.	Find out specific rate constant and activation energy of a reaction in a plug flow reactor.
16.	Use MATLAB software to simulate Batch / CSTR / Plug flow reactor data.

Text Books/References:

1.	Octave Levenspiel, "Chemical Reaction Engineering", 3rd Edition, John Wiley and sons, New Delhi, 2007. (ISBN 9788126510009).
2.	Scott Fogler H, "Elements of Chemical Reaction Engineering", 4th Edition, Prentice Hall of India, New Delhi, 2006. (ISBN : 9788120334168).
3.	Keith J. Laidler, "Chemical Kinetics", 3rd Edition, Pearson Education Inc. (ISBN: 9788131709726).
4.	Smith J.M., "Chemical Engineering kinetics", 3rd Edition, McGraw Hill, 1981. (ISBN: 0070665745).

Syllabus for Unit Test:

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

CHEMICAL ENGINEERING MATHEMATICS		
Designation: Professional Core		
Course Pre-requisites:		
Students should have		
Basic knowledge of Mathematics including derivative, integration etc.		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3Hours/Week	End Semester Examination: 60 Marks	Theory : 03
Tutorial : 1Hour/Week	Unit Test: 20 Marks	Tutorial : 01
	Continuous Assessment: 20 Marks	Total credits: 04
	Term work / Oral:50 Marks	
	Total: 150	

Course Outcomes:

After completion of the course students will be able to

1.	Compute the roots of the equation using methods like Secant method, Bisection method, False position method etc.
2.	Apply Numerical differentiation methods such Euler's method, Modified Euler's method, Runge-Kutta methods etc.
3.	Apply Numerical integration methods such as Trapezoidal rule, Simpson method, Romberg method etc.
4.	Evaluate the problems on special matrices using Matrix inversion method, LU decomposition etc.
5.	Evaluate curve fitting problems.
6.	Optimize Linear programming problems.

Topics covered

UNIT-I	**Root of equation** Solve Fluid flow, heat transfer problems using Picard method, Secant method, Bisection method, False position method, Newton-Rapson method, modified Newton-Rapson method, Muller method.	**(06 Hours)**
UNIT-II	**Numerical Differentiation** Solve mass transfer, chemical reaction engineering, heat transfer problems using Euler's method, Modified Euler's method, Runge-Kutta methods, Milne's predictor-corrector method, Richardson Extrapolation.	**(06 Hours)**
UNIT-III	**Numerical Integration** Trapezoidal rule, Simpson 1/3 and 3/8 rule, Multiple integrals, Romberg integration, Stirlings formula, LaGarange method, Cauchys integral formula.	**(06 Hours)**

UNIT-IV	**Multiple algebraic equations using Matrix** Matrix inversion method, Gauss elimination, Gauss Jordan method, LU decomposition method, Gauss Seidal method, Jacobian method.	**(06 Hours)**
UNIT-V	**Curve fitting and Statistics** Linear regression, multiple linear regressions, polynomial regression, general linear least squares, Non-linear regression. Introduction to Statistics, application of Statistics, histogram method, measuring centre values by median, mode methods.	**(06 Hours)**
UNIT-VI	**Optimization** Graphical method, Simplex method, Golden section search method, Linear programming case studies such as least cost design of tank, least cost treatment of wastewater, chemical Process e.g. reactors, heat exchangers, evaporators etc.	**(06 Hours)**

Assignments:

There will be six (6) assignments from various units mentioned in the syllabus. Each assignment will carry 10 marks.

List of assignments

1. Finding the roots of polymeric equations mentioned in the fluid mechanics. Equations such as buoyancy of ball, liquid level in manometer etc.
2. Solving the equations from mass transfer, Momentum transfer using Numerical differentiation methods.
3. Evaluating the integrals from heat transfer using Numerical integral methods.
4. Solving linear problems from process calculation using matrix methods.
5. Finding rate equation, equilibrium curve using experimental data.
6. Applying optimization method for equation of cost for various equipments, insulation thickness etc.
7. With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry
8. Solve old (last five years) question papers with reference to particular topic.
9. Solve old (last ten years) GATE question papers with reference to chemical engineering mathematics subject.

Tutorials / Term work

1. Solving problems on roots of equation.
2. Use numerical differential methods for problems on chemical reaction engineering, mass transfer, heat transfer etc.
3. Use numerical integration methods for problems on chemical reaction engineering, mass transfer, heat transfer etc.
4. Solve problems on multiple algebraic equations using Matrix.
5. Analyze and solve the problems on curve fitting.
6. Applying optimization method for industrial problems.

Text Books/References:	
1.	Chapra S. C., R.P. Canale, “Numerical Methods for Engineers”, Tata-McGraw Hill Publications.
2.	T. F. Edgar, D. M. Himmblblau. , “Optimization of Chemical Processes”, Tata-McGraw Hill Publications.
3.	M. K. Jain, S. R .K. Iyengar, R. K. Jain. , “Numerical methods for Scientific and Engineering Computational”, new age international Publishers.
4.	S. S. Sastri. , “Introductory methods of Numerical analysis”, Prentice-Hall India.
5.	S. Pushpavanam, “Mathematical Methods for Chemical Engineering”, Printice-Hall of India.
6.	E. Balagurusamy. , “Numerical Methods”, McGraw Hill Education (India) Private Limited.

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

COMPUTER PROGRAMMING FOR CHEMICAL ENGINEERS - I		
Designation: Computing		
Course Pre-requisites:		
Students should have basic knowledge of		
Computer fundamentals		
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
Total : 5Hours/Week	Term work / practical : 50 Marks	Total credits : 04
	Total :150 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	Apply the knowledge of constant, variables and data types used in visual basic and write programs.
2.	Write coding in VB and prepare interface using various controls like option button, check box, list box, text box, command button etc.
3.	Apply the knowledge of Visual Basic to various chemical engineering calculations.
4.	Explain and apply the HTML tags for web page.
5.	Design a web page and apply dynamic effects to the page using the knowledge of HTML.
6.	Explain and apply the various DHTML tags and object models for web page.

Topics covered

UNIT-I	**Visual Basic:** Introduction to visual basic, object oriented programming and Graphics User Interface (GUI). Editions of visual basic. Variable: Types of variable declaration, scope of variable. Data Types, conversion of data types, array of controls. Control constructs and loop statements used in visual basic.	**(06 Hours)**
UNIT-II	Important Visual Basic controls like Text box, command button, option button, check box, list box, combo box, frame, label and Timer contol. Events: mouse, key and focus events. Working with menus, toolbars, status bars. Scope of variables and procedures. Data controls. Creating MDI applications.	**(06 Hours)**
UNIT-III	Application of Visual Basic for Chemical Engineering: Various calculations and solutions in chemical engineering like calculation of LMTD for co-current and counter current heat exchangers, Design of distillation column, evaporator, dryer, mixed flow reactor etc.	**(06 Hours)**
UNIT-IV	**HTML:** Introduction toHTML, components of HTML, structure tags, block level tags, text level tags, horizontal rules, colours in web page. Design parameters.List: ordered, unordered and definition list, generating lists.	**(06 Hours)**
UNIT-V	Web page designing parameters. Adding graphics/images. Hyperlinks. Tables. Frames. Style sheets. Applying dynamic effects to the page. Working with forms in a web page	**(06 Hours)**
UNIT-VI	**DHTML**:	**(06 Hours)**

	Introduction to DHTML, DHTML Object Model. Events. Handing text attributes. Dynamically changing style. Dynamically changing content. Dynamically altering the placement of elements	

Assignments	
1.	Discuss the client-server applications with appropriate example
2.	Discuss web applications with appropriate example
3.	Explain e-commerce applications
4.	Design your own home page using various HTML tags
5.	Design your own blog for technical discussion.
6.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
7.	To create various animations using Timer control.
8.	Design various unit operations used in chemical industry using knowledge of visual basic.
9.	Students have to study any five NPTEL videos related to HTML, DHTML and visual basic and prepare/present power point presentation.
10.	Programs based on above six units.
11.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.
12.	Group discussion on the recent advances in HTML, DHTML and visual basic.
13.	Technical interview based on the knowledge of HTML, DHTML and visual basic.
In addition to these above stated assignments concerned faculty member may design his/her own assignments	
Term Work:	
Term work will consist of the programs/practicals listed below, out of which any eight programs/practicals are to be performed in laboratory by the students.	
1.	Development of visual basic interface and programs using click events.
2.	Development of visual basic interface and programs using option button.
3.	Development of visual basic interface and programs using list box control.
4	Development of visual basic interface and programs using various control statements
5.	Development of visual basic interface and programs using various loop statements
6.	Development of visual basic interface and programs using Timer control.
7.	Application of visual basic to various chemical engineering calculations.
8.	To create table and use of table tags in HTML to design a web page.
9.	Web page design as per given output
10.	Design a web page using the image and hyperlink.
11.	Design a web page using ordered list, unordered list and definition list.
12.	HTML code to display given form.
Text Books/References:	
1.	Holzschlag, M. E.; Using HTML – 4, Eastern Economy Publication
2.	Holzner, S. ; HTML Black Book, Dreamtech Press
3.	Thomas Powell; HTML& CSS: The Complete reference, 5th edition," BPB Publications
4.	Gurewich; Learn VB In 21 Days, San's Publications
5.	Cornell; Visual Basic 6 from the ground, Tata McGraw Hill Publishers
6.	Hollis; Visual Basic 6 : Design, specification & Objects, Longman Publications

7.	Ivan Bayross; Web Enabled Commercial Application Development Using HTML, DHTML, JavaScript, Perl CGI, PBP Publications.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,IV
Unit Test -II	UNIT – III,V,VI

ELECTIVE II BIOFUEL TECHNOLOGY

Designation: Elective

Course Pre-requisites:

Students should have basic knowledge of

1	Biology
2	Basics of Chemical Engineering

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

Course Outcomes:

After completion of the course students would be able to describe

1.	How petroleum and bio-based fuels affect the global carbon cycle
2.	The attributes of biofuels that make them suitable as a fuel for a specific application
3.	Limitations of petroleum fuel and biofuel and importance of biodiesel
4.	Global impacts of bioethanol and biobutanol on energy sector
5.	Technological advances and challenges to be overcome for biohydrogen production
6.	Importance and aspects of manufacturing processes of microbial fuel cells

Topics covered

UNIT-I	**Introduction to Biofuels:** Biofuels, energy use and efficiency, generations of biofuels, alternative energies, types of biofuels, advantages and disadvantages of different biofuels, economics, and policies.	**(06 Hours)**
UNIT-II	**Renewable Feedstocks:** Feedstocks: Biomass, starch, sugar, lignocellulosic, agro and industrial by-products, pretreatment of feedstock, biomass production for fuel – algal cultures, yeasts (lipid and carbohydrate), sources of oils – edible and non edible	**(06 Hours)**
UNIT-III	**Production of biodiesel:** Chemical, thermodynamic and reaction kinetic aspects of biodiesel production: esterification and transesterification, free fatty acids; saponification; single step and two step biodiesel production, catalysts for biodiesel production – homogeneous (alkali/acidic) and heterogeneous, general procedure of biodiesel production and purification. algal biodiesel production, quality control aspects, methods to improve the biodiesel yield, process flow diagrams	**(06 Hours)**
UNIT-IV	**Production of bioethanol and biobutanol:** Process technology for ABE using different feedstocks; by-products of biofuel industry as feedstock; selection of micro-organisms and feedstock – ethanol/butanol tolerance; determination of ABE yield; recovery of biofuels, process integration, advances in bioethanol and biobutanol production.	**(06 Hours)**

UNIT-V	**Production of Biohydrogen:** Enzymes involved in H_2 production; photobiological H_2 production: biophotolysis and photo-fermentation; H_2 production by fermentation: biochemical pathway, batch fermentation, factors affecting H_2 production, carbon sources, process and culture parameters; detection and quantification of H_2, reactors for biohydrogen production. **Biogas**: Use of different feedstock to produce biogas, methods of biogas generation, equipment design to improve the yield, application of biogas as fuel	**(06 Hours)**
UNIT-VI	**Microbial Fuel Cells (MFC):** Biochemical basis; components of MFC fuel cell design, microbial cultures, MFC performance methods: substrate and biomass measurements, basic power calculations, MFC performance, single vs two-chamber designs, Applications of MFC	**(06 Hours)**

Text Books/References:

1.	C.M. Drapcho, N.P. Nhuan, T.H. Walker. Biofuels Engineering Process Technology, Mc Graw Hill Publishers, New York, 2008.
2.	R.M. Jonathan. Biofuels – Methods and Protocols (Methods in Molecular Biology Series), Humana Press, New York, 2009.
3.	L. Olsson (Ed.), Biofuels (Advances in Biochemical Engineering/Biotechnology Series, Springer-Verlag Publishers, Berlin, 2007.
4.	A.N. Glazer, H. Nikaido, Microbial Biotechnology – Fundamentals of Applied Microbiology, 2 Ed., Cambridge University Press, 2007.
5.	R. C. Brown, Biorenewable Resources: Engineering New Products from Agriculture, Wiley-Blackwell Publishing (2003)

Syllabus for Unit Test:

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

ELECTIVE II FOOD TECHNOLOGY		
Designation: Elective		
Course Pre-requisites:		
Basic knowledge of microbiology and biochemistry		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 3 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
Seminar : -	Unit Test : 20 Marks	Seminar : -
Total : 3 Hours/Week	Continuous Assessment : 20 Marks	Total credits : 03
	Total : 100 Marks	

Course Outcomes:

After completion of the course students would be able to

1.	Evaluate analysis of suitable chemical constitute and their significance in food products.
2.	Identify the significance of fluid flow and rheological properties of food; develop the Process and equipment design aspect for food processing.
3.	Draw basic flow sheet development for food processing, construction and plant layout.
4.	Implement suitable equipment design and their design parameters for canning and retort processing.
5.	Chose and apply suitable food preservation technique, give details of preservation, significance and estimate economy of the food preservation.
6.	Select and do the packaging of fresh food and processed food, implement newer trends in packaging.

Topics covered

UNIT-I	**Introduction to food technology :** Introduction to food technology, different types of food products, Application of Engineering in Food industries. Analysis of chemical constituents in food products, their characterization and significance.	**(06 Hours)**
UNIT-II	**Food Engineering:** Principles of mass and energy balance in food processing operations. Transport phenomena with respect to foods. Fluid dynamics, Rheological properties of foods. Process design aspects. Concentration with thermal and membranes processes. Process and equipment design for food processing.	**(06 Hours)**
UNIT-III	**Food Process Engineering:** Important aspects of product and process development. Basic flow sheet development for food processing. Other food processing such as Bakery machines and equipment; Food processing plant layout, material of construction, corrosion, waste utilization.	**(06 Hours)**
UNIT-IV	**Thermal processing:** Canning and retort processing – process design and equipment. Equipment design aspects, dryers and their design parameters. Construction of cold	**(06 Hours)**

	storages, Types of freezers and their design parameters	
UNIT-V	**Principles of food preservation:** Aims and objectives of preservation and processing of foods**.** Preservation by high temperature, Preservation by low temperature, Preservation by water removal. Different preservation technique: chemical preservatives. Controlled and modified atmospheric storage.	**(06 Hours)**
UNIT-VI	**Food Packaging Technology:** Concept of packaging, Functions of a Food Package, Aseptic Packaging. Packaging as a method for conservation and protection of foods. Different packaging materials and their properties, Environmental friendly food packing material, Food product characteristics and package requirement, Evaluation of quality and safety of packaging materials.	**(06 Hours)**

Text Books/References:

1.	The Fundamentals of Food Engineering, Charm SE, 1963, The Avi Publishing Co.
2.	S. Saclarow and R.C. Griffin. Principles of Food Packaging
3.	RS Kirk and R. Sawyer.1991. Pearson's Chemical Analysis of Foods. 9th Ed. Harlow, UK, Longman Scientific and Technical.
4.	M. Mathlouthi. Food Packaging and Preservation : theory and practice, Springer Science
5.	R.T. Toledo. Fundamentals of Food Process Engineering, 2000, Chapman and Hall.
6.	N.W. Desrosier. The Technology of Food Preservation, 1977, The AVI Publishing Co. Inc.
7.	P.J. Fellows. Food Processing Technology: Principles and Practice, 2005, CBS Publishers.
8.	D.R. Heldman and R.P. Singh. Food Process Engineering, 1984, Chapman and Hall.
9.	J.M. Apple. Plant Layout and Material Handling, 1977, John Wiley & Sons.

Syllabus for Unit Test:

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

ELECTIVE-II NANOMATERIALS			
Designation: Elective			
Course Pre-requisites:			
Students should have knowledge of			
1.	Chemistry, Physics		
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.	Define the concept of nanomaterials and Nanotechnology		
2.	Express various types of nanomaterials and characterization techniques		
3.	Distinguish between the synthesis techniques for nanomaterials and apply the appropriate synthesis technique.		
4.	Recognize the properties of nanomaterials and effect on them due to nanoscale.		
5.	Express the Chemical and Catalytic Aspects of Nanomaterials		
6.	Recognize the various modes and methods for synthesis of polymer nanocomposite		
Topics covered			
UNIT - I	**Introduction to Nanomaterials** Basic definitions: Nanoscience, Nanotechnology, Nanomaterial, Nanostructure, Nanomachine; Historical perspective on nanomaterials, Advantages of nanomaterials, Importance of nanomaterials, Top down and bottom up approaches to manufacture nanomaterials. Applications of Nanomaterials **Types of nanomaterial/Nanostructures** Classification of nanomaterial based on the number of dimensions: 0-D, 1-D, 2-D, and 3-D nanostructures; Quantum dots, Quantum wire, Core/Shell structures, Nanotubes, nanorodes, nanowires, nanofibers.		**(06 Hours)**
UNIT - II	**Characterization Techniques**: X-ray Diffraction, Scanning Electron Microscopy (SEM), Transmission Electron microscopy (TEM), Optical spectroscopy, Atomic Force Micrograph (AFM), Partical Size Analyzer. **Synthesis of Nanomaterials:** Classification of Nanoparticle Synthesis Techniques, Solid-State Synthesis of Nanoparticles, Vapor-Phase Synthesis of Nanoparticles, Inert Gas Condensation of Nanoparticles, Chemical Vapor Condensation (CVC),		**(06 Hours)**
UNIT - III	**Technology of Nanoparticles Synthesis:** Plasma-Based Synthesis of Nanoparticles, Flame-Based Synthesis of Nanoparticles, Spray Pyrolysis of Nanoparticles; Solution Processing of Nanoparticles, Sol-Gel Processing, Solution Precipitation, Water–Oil		**(06 Hours)**

	Microemulsion (Reverse Micelle) Method.	
UNIT - IV	**Nanomaterial properties** Physical properties of nanostructured materials, Chemical properties, Mechanical properties, Magnetic and structural properties, Optical properties, Thermal properties; Influence of nano structuring on mechanical, optical, electronic, magnetic and chemical properties**;** Gramsize effects on strength of metals optical properties of quantum dots and quantum wires, carbon nano tubes: magnetic behavior.	**(06 Hours)**
UNIT - V	**Chemical and Catalytic Aspects of Nanomaterials** Nanomaterials in catalysis, Importance of surface to volume ratios, nanocrystal shapes and defects as they relate to heterogeneous catalysis, Controlled pore size materials, nanoparticles as chemical reagents; Examples of metal, metal oxide and metal sulfide nanoparticles in catalytic processes	**(06 Hours)**
UNIT - VI	**Polymer Nanocomposites** Generalities on polymer composites, From "Micro" to "Nano" composites: Effect of particle dimensions, Nanocomposites preparation pathways: Importance of the interfacial compatibilization, Current scientific and technical advances in polymer nanocomposites	**(06 Hours)**

Tutorials/Assignments:

The internal assessment shall consist of minimum SIX assignments from the following list

1.	Questions involving classification of nanomaterial
2.	Prepare one assignment considering any one nanomaterial on: Influence of Nano structuring on Mechanical - Optical, electronic, magnetic and chemical properties
3.	Conducting surprise MCQ test for students
4.	Questions involving various techniques employed for nanomaterial characterization
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 in nanomaterials and prepare/present power point presentation
7.	Brief report on 'Environmental, health and ethical concerns that are associated with nanomaterials
8.	Group discussions on any of the following topics: a) Importance of Nanomaterials in chemical industries. b) Current scientific and technical advances in Nanomaterials c) Methods of synthesis for nanomaterials
9.	Preparation of a brief report on applicability of nanomaterials in chemical engineering operations
10.	Conducting open-book class test

Text Books/ References:

1.	Charles P. Poole, Frank J. Owens, "Introduction to Nanotechnology", Wiley Interscience
2.	B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday, "Textbook of Nanoscience and Nanotechnology" Universities Press (India) Private Limited
3.	Mark A. Ratner, Daniel Ratner, "Nanotechnology: A gentle introduction to the next Big Idea", Prentice Hall, 1st Edition

4.	Yury Gogotsi, “Nanomaterials Handbook”, CRC Press, Taylor & Francis Group
5.	Gu¨nter Schmid, “Nanoparticles From Theory to Application”, Wiley-VCH Verlag GmbH & Co
6.	C. Br´echignac P. Houdy M. Lahmani, “Nanomaterials and Nanochemistry”, Springer Berlin Heidelberg New York
7.	Kenneth J. Klabunde, “Nanoscale Materials in Chemistry”, John Wiley & Sons, Inc
8.	Alain Nouailhat, “An Introduction to Nanoscience and Nanotechnology”, Wiley-ISTE; 1st Edition

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

Elective I: Polymer Technology			
Designation: Elective			
Course Pre-requisites:			
1.	Basic chemistry, Physical chemistry, Chemical Reaction Engineering, Chemical Engineering Thermodynamics		
TEACHING SCHEME:		**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hours/Week		End Semester Examination: 60 marks	Theory : 03
		Continuous Assessment: 40 marks	
Course Outcomes:			
1.	Explain basics of polymers and their classifications		
2.	Explain various polymer properties and the their effect on engineering properties		
3.	Determine suitable process for polymer synthesis and describe its mechanism		
4.	Understand the basics of polymer characterizations and discuss its effect on properties		
5.	Explain the formation of composites and blends in polymers		
6.	Explain the methods of polymer compounding and processing		
Topics covered			
UNIT-I	**Introduction to polymers** Introduction, polymer microstructure, homopolymers-heteropolymers, monomers as building block of polymers, historical development, classifications of polymers and polymerization reactions, chain growth and step growth polymerization, mechanism of polymerization, polymer liquids and polymer solids		**(06 Hours)**
UNIT-II	**Polymer properties** Molecular weight of polymers (Mw, Mn, Mv), Molecular weight distribution, determination of molecular weights, polymer morphology, polymer structure – linear, branched and crosslinked, presence of functionality, chemical bonding in polymers, sterioisomerism, effect these factors on chemical, thermal and mechanical properties of polymers		**(06 Hours)**
UNIT-III	**Synthesis of polymers** Polymerization techniques: bulk, solution, suspension, emulsion polymerization with their merits and demerits, kinetics of polymerization; free radical chain polymerization, cationic polymerization, anionic polymerization, polycondensation, co-polymerization and its kinetics, Smith Ewarts kinetics for emulsion polymerization, continuous emulsion polymerization, Ziegler-Natta catalyst		**(06 Hours)**
UNIT-IV	**Polymer structure and effect on properties** Chemical and geometrical structure of polymer molecules, microstructure based on chemical structure, microstructure based on geometrical structure, Glass transition temperature, factors influencing glass transition – molecular		**(06 Hours)**

	weight, plasticisers, copolymer concentration, and their effect on polymer properties; crystallinity, effect of presence of crystallinity on polymer properties	
UNIT-V	**Polymer composite and blends** Difference between blends and composites, their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites.	**(06 Hours)**
UNIT-VI	**Polymer processing and compounding** Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, crosslinking and vulcanization. Methods of processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.	**(06 Hours)**

Assignments:

1.	Prepare the report on any one polymer comprising its significance, preparation, characterization, processing and properties

References/Text Books:

1.	Text book for polymer science; F. W. Billmeyer, Wiley Interscience Publications (John Wiley and Sons)
2.	Polymer Science, V. R. Gowarikar, N. V. Viswanathan, J. Shreedhar; Wiley Estern Limited
3.	Principles of Polymerizations; Odion G. G.; Mc-Graw Hill
4.	Fundamentals of polymer Engineering, Arie Ram, Plenum Press
5.	Polymer Physics, Michael Rubinstein, Ralph H. Colby, Wiley Interscience Publications (John Wiley and Sons)
6.	Polymer data handbook, James E. Mark (Ed.), Oxford University Press

Syllabus for Unit Test:

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

SEPARATION TECHNIQUES		
Designation: Professional Core		
Course Pre-requisites:		
Students should have basic knowledge of		
1	Fundamentals of mass transfer	
2	Fundamentals of heat transfer	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 4 Hours/Week	End Semester Examination: 60 Marks	Theory : 04
Practical : 2 Hour /Week	Unit Test: 20 Marks	Practical: 01
Total : 6Hours/Week	Continuous Assessment: 20 Marks	Total credits: 05
	Term work / practical:50 Marks	
	Total :150 Marks	

Course Outcomes:	
After completion of the course students would be able to	
1.	Apply the basics of distillation for the binary separation of ideal and nonideal mixture and determine the extent of separation obtained.
2.	Describe the operation of continuous rectification and determine the number of stages required for distillation.
3.	Determine the number of stages required for separation using liquid-liquid extraction and describe the extractors used industrially.
4.	Obtain the requirement of solvent in leaching operation and obtain the extent of separation.
5.	Plot the adsorption isotherms and estimate the amount of adsorption using single and multistage operations.
6.	Explain the operation and applications of novel separation techniques

Topics covered

UNIT-I	**Introduction:** Review of various separation techniques, Selection of the technique of separation, pros and cons of various methods. **Basics of Distillation:** Equilibrium of vapor and liquid, relative volatility, Raoult's law, Ideal and Non-ideal behavior study, Azeotropes, positive and negative deviation from ideality, Methods of distillation - simple, flash distillation, Rayleigh's equation, Graphical and analytical method for determination of the compositions, Introduction to reactive distillation, Azeotropic distillation, Molecular or low pressure distillation, Extractive distillation.	**(08 Hours)**
UNIT-II	**Rectification:** Continuous rectification for binary systems, Tray towers, McCabe Thiele's method of calculation of number of trays, Method of Ponchon Savarit, Enthalpy concentration diagrams, Tray efficiencies, Concept of reflux, cold reflux, partial and total cold reflux, Effect of feed temperature and q-line equation derivation, Total reflux, Optimum reflux, Fenske Underwood equation, Condenser and reboilers used in distillation, Use of open steam for	**(08 Hours)**

	distillation, Rectification of Azeotropic mixtures. Distillation in packed towers: HETP concept, HTU and NTU calculations, Distillation column internals: Type of trays, Type of packing used.	
UNIT-III	**Adsorption:** Types of adsorption, Nature of adsorbents, Equilibria in adsorption- Single gases and vapors, adsorption hysteresis, Effect of temperature, Heat of adsorption, adsorption of liquids, Langmuir isotherms, Freundlich isotherms, Introduction to pressure swing and temperature swing adsorption, Equipment: Continuous contact, Steady state moving bed absorbers. **Ion exchange process**: Basic principles and chemical reactions, Techniques and applications, Equilibria and rate of ion exchange, Equipment studies.	**(08 Hours)**
UNIT-IV	**Liquid- Liquid Extraction:** Introduction, Choice of solvent, Ternary equilibrium, Binodal solubility curve, Single stage extraction, Multistage crosscurrent and countercurrent extraction, extraction calculations using triangular and rectangular coordinates, Solvent free basis calculations, Nxy diagrams, Material balances, Continuous countercurrent extraction with reflux, stage efficiency. Continuous countercurrent extraction in packed columns: HTU and NTU calculations. Types of extractors: Stage type and differential extractors.	**(08 Hours)**
UNIT-V	**Leaching (Solid Liquid Extraction):** Introduction: Classification of leaching processes, Factors affecting the leaching process, Solid –liquid equilibria. Methods of calculation: Single stage leaching, multistage cross-current leaching, Continuous countercurrent leaching. Leaching Equipments: Unsteady state and steady state equipment.	**(08 Hours)**
UNIT-VI	**Novel separation techniques:** Membrane separation techniques- Ultrafiltration, Nano-filtration, Reverse osmosis process, Electro dialysis, Rate based processes such as diffusion coefficient based inert gas generating from air by carbon molecular sieves.	**(08 Hours)**

Assignments	
1.	Group discussion on the recent advances in mass transfer operations.
2.	Solve previous university question papers with reference to particular topic of this subject.
3.	Seminar presentation on a particular topic specified in the syllabus and submission of report based on it.
4.	Estimation of composition of vapor and liquid in flash distillation
5.	Compute the composition of residue and distillate in simple distillation.
6.	Evaluation of number of stages using McCabe Thiele and Ponchon Savarit method.
7.	HTU and NTU calculation for distillation in packed columns.
8.	Group discussion on equipments used for extraction.
9.	Estimate the number of stages required for single and multistage extraction operation.
10.	Estimate the number of stages required for single and multistage leaching operation.
11.	Group discussion on ion exchange technique and its application.
12.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in industry.

13.	Presentation on novel separation techniques.
14.	Solve old GATE question papers with reference to this subject.
15.	Group discussion on the recent advances in separation techniques.
16.	Write a report on your visit to research and development laboratory of national/international repute.
17.	Technical interview based on the knowledge of separation techniques.

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.	Simple distillation
2.	Distillation with total reflux
3.	Steam distillation
4	Equilibrium diagrams for liquid -liquid extraction
5.	Cross current multistage extraction
6.	York Schiebel column for extraction
7.	Bubble cap distillation column
8.	Sieve tray distillation column
9.	Vapour liquid equilibria
10.	Solid liquid extraction of oil
11.	Langmuir and Freundlich adsorption isotherm

Text Books/References:

1.	Treybal R. E., “Mass Transfer Operation”,McGraw Hill publication.
2.	Coulson J. M. Richardson, “Chemical engineering", Vol, I and II, Pergamon Press.
3.	King C. J., “Separation Techniques”, McGraw Hill publication.
4.	Smith B. D., “Design of Equilibrium stage process”, McGraw Hill publication.

Syllabus for Unit Test:

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

CHEMICAL PROCESS EQUIPMENT DESIGN-I		
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:25 Marks	
	Total :125 Marks	

Course Outcomes:	
After completion of the course students would be able to	
1.	Apply and understand different codes for equipment design.
2.	Deign different heads used for equipments
3.	Identify and design different supports used for process equipments.
4.	Study and design process and mechanical aspect of heat exchangers
5.	Calculate various stresses acting on vessels
6.	Design different equipments like cyclone separator, gravity thickener, decanter, fluid –fluid separator, electrostatic precipitator, cooling towers, evaporators, dryers, crystallizers.

Topics covered		
UNIT-I	**Introduction to Process Equipment Design:** Introduction to various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of temperature and pressure etc. Theories of failures, application and use of various codes and standards in design. Representation of different utilities and symbols, General design procedure, equipment classification, study of design parameters such as maximum working pressure, design pressure, design temperature, design stress & factor of safety, design of wall thickness & minimum actual thickness, corrosion allowance, design loading, possions ratio.	**(06 Hours)**
UNIT-II	**Design of pressure vessels and storage tank:** Design of pressure vessels and storage tank: Vessels subjected to internal pressure and combined loading, cylindrical and spherical shell, resultant stresses induced in pressure vessel, stresses in high pressure vessels, optimum vessel size, design of various heads & closures such as flat head, torrispherial head, elliptical head, hemispherical head, and conical head. Design of storage tank, types of storage tank, types of roof for storage tank, types of losses in floating roof tank, estimation of nozzle diameter for drain in storage tank.	**(06 Hours)**
UNIT-III	**Introduction to various Supports :**	**(06 Hours)**

	Introduction to various Supports, design of various supports such as skirt support, skirt bearing plate, leg support, bracket support, saddle support, design of tall vertical column, anchor bolts, base ring, ring stiffeners, wind girders, flanges & nozzles, detail design of number of bolts & nozzles. Stresses induced in supports like dead weight, wind load, seismic load.	
UNIT-IV	**Design of Heat exchangers** : Classification of heat exchangers, flow arrangements, types of heat exchanger, LMTD and effectiveness NTU method, Process design of shell and tube heat exchanger - heat transfer coefficient calculations, number of tube calculation, pressure drop calculation on tube side and shell side. Process design of double pipe heat exchanger, types of fouling, fouling resistance in heat exchangers. Mechanical design aspects of heat exchanger. Differential expansion and thermal stresses in heat exchanger. Introduction to fin type, plate type heat exchanger.	**(06 Hours)**
UNIT-V	**Design of Agitators** : Design of Agitators: types of agitators, selection criteria, design of blades, power calculation, flow patterns, calculation of bending moment, twisting moment, and combined effect.	**(06 Hours)**
UNIT-VI	**Design of some separation equipments** : Design of some separation equipment like cyclone separator, gravity thickener, decanter, fluid –fluid separator, electrostatic precipitator, evaporators.	**(06 Hours)**

Assignments	
1.	Write a report on different codes and symbols used in design.
2.	Solve old (last five years) question papers with reference to particular topic.
3.	Prepare a model for any of the equipment
4.	Prepare a report on advance equipments which are newly introduced in the current year.
5.	Give fifteen minutes presentation (seminar) on particular topic and prepare a report.
6.	Prepare model for different roofs used in storage vessels.
7.	Prepare a chart for different construction of materials in equipment design.
8.	Prepare a presentations on newly introduced equipments in current year
9.	Design laboratory manuals better than existing ones with clearly shown specimen calculations.
10.	With the help of this subject knowledge, write a guideline report on how you would apply your concepts in designing a economic plant layout for any industry.
11.	Write a technical report on your visit to a process industry.
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.	Detailed design and drawing of enclosures and supports
2.	Design of pressure vessels.
3.	Calculation of heat transfer coefficient, No of tubes and rate of heat flow in shell and tube heat exchanger
4	Calculate pressure drop for tube and shell side heat exchanger.
5.	Detailed design and drawing of agitated vessel.
6.	Detailed design and drawing of cyclone separator.
7.	Detailed design and drawing of cooling towers
8.	Detailed design and drawing of crystallizer
9.	Detailed design and drawing of gravity thickener.
10.	Design of storage tanks.
11.	Design of Supports.
12	Calculation of heat transfer coefficient,rate of heat flow and effectiveness in Double pipe heat exchanger.
13	Calculation of heat transfer coefficient,rate of heat flow and effectiveness in fin type heat exchanger.
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

CHEMICAL REACTION ENGINEERING-II			
Designation: Professional Core			
Course Pre-requisites:			
Students should have basic knowledge of			
1	Chemical reaction engineering-I		
2	Stiochiometry		
3.	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
		Term work / Oral :50 Marks	
		Total :150 Marks	
Course Outcomes:			
After completion of the course students would be able to			
1.	a) Write the overall rate equation for heterogeneous reactions. b) Study kinetics and design of fluid solid non catalytic reactions.		
2.	Define the mechanism of catalytic reactions.		
3.	Calculate the height of fluid fluid non catalytic reactions.		
4.	Learn the kinetics and design of solid catalyzed reactions.		
5.	Learn the diffusion and reaction kinetics for porous catalyst.		
6.	Develop the kinetics of nonideal flow.		
Topics covered			
UNIT-I	**Introduction to heterogeneous reaction systems:** **Fluid-solid non catalytic reactions:** Types of heterogeneous reactions. Steps involved in developing overall rate equation. Linearizing a nonlinear rate equation and contacting patterns for heterogeneous reaction systems. Proposed models i.e. progressive conversion model and unreacted core model. Steps/resistance involved in these models. Individual and overall/global rate equation. Determination of rate controlling step. Application to design of fluid solid reactor by identifying the type of flow of phases.		**(06 Hours)**
UNIT-II	**Fluid-fluid non catalytic reactions:** Kinetic regimes for mass transfer and reaction. Rate equation for different cases/regimes. Clues to kinetic regimes using different methods. Application to design of packed bed reactor.		**(06Hours)**
UNIT-III	**Catalysis (fluid-solid catalytic reactions):** The nature of catalytic reactions. The mechanism of catalytic reactions. Steps involved in catalytic reactions. Types of adsorption, Langmuir adsorption isotherm. Synthesizing a rate law rate limiting step, preparation of catalyst and its deactivation, poisoning and regeneration. Nature and mechanism of catalyst reactions.		**(06 Hours)**
UNIT-IV	**Solid catalyzed reactions:**		**(06Hours)**

	Introduction, Rate equation, Film resistance controlling, surface flow controlling , Pore diffusion controlling, Experimental methods for finding rates, construction, operation and design of Catalytic reactors : Fixed bed reactor, Fluidized bed reactor.	
UNIT-V	**Diffusion and reaction in porous catalysts**: Diffusion and reaction in spherical catalyst pellets. Internal effectiveness factor. Overall effectiveness factor. Estimation of diffusion- and reaction-limited regimes. Mass transfer and reaction in a packed-bed. Chemical vapor decomposition (CVD) reactors.	**(06Hours)**
UNIT-VI	**Basics of Non-ideal Flow:** The Residence Time Distribution Functions and their Relationships Role of RTD in determining reactor behavior Experimental methods for finding E, the pulse experiment, the step experiment, relationship between E, F & C curve. Introduction to Dispersion Model, Tank in series model.	**(06Hours)**

Assignments

1.	List different types of heterogeneous reactions in chemical industry.
2.	Write a report on " Importance of heterogeneous reactions in Chemical Industry"
3.	Select any five industrial heterogeneous reactions and write rate equations for the reactions.
4.	Give power point presentation on models for heterogeneous reactions.
5.	Design a reactor for fluid solid non catalytic reactions.
6.	Do the experiments on Reactor lab software.
7.	Give power point presentation on different types of adsorption isotherms.
8.	Solve any five old question papers.
9.	Solve ten problems on kinetics and design of fluid fluid non catalytic reactions.
10.	List out different types if industrial catalyst with characteristics.
11.	Draw different types of contacting patterns for heterogeneous reactions used in industry.
12.	Give a presentation on any reactor used for heterogeneous reactions in industry
13.	Write a report on research (review) paper on reactors used for heterogeneous reactions.
14.	Industrial visit to a chemical industry.
15.	Write a report on industrial visit. Give emphasis on details of reactor.

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.	To study residence time distribution in packed bed reactor.
2.	To study residence time distribution in plug flow reactor.
3.	To study residence time distribution in continuous stirred tank reactor.
4	To study CSTR PFR in series.
5.	To study CSTR in series.
6.	Determination Surface area of catalysts.
7.	Determination of bulk density, apparent density, and true density of catalyst.
8.	Determination Pore volume of catalysts.

Text Books/References:	
1.	Levenspiel Octave. “Chemical Reaction Engineering,” Wiley Eastern Publications
2.	Smith J.M. “Chemical Engineering Kinetics,” McGraw-Hill Publications
3.	Fogler H.S. “Elements of Chemical Reaction Engineering,” Eastern Economy Publications
4.	Carberry & Verma “Chemical and Catalytic Reaction Engineering”
5.	H. Scott Fogler “Elements of Chemical Reaction Engineering”
6.	Doraiswamy L.K. and Sharma M.M. “Heterogeneous Reactions: Analysis Examples and reactor design.” Vol.1 & 2.
7.	C.G. Hill. “An Introduction to Chemical Reaction Kinetics & Reactor Design.”
8.	Dawande, “Principles of Reaction Engineering.” Denett publications

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

PROCESS INSTRUMENTATION AND INTRUMENTAL METHODS OF ANALYSIS		
Designation: Professional Core		
Course Pre-requisites:		
Students should have		
	Basic knowledge of Mathematics.	
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures: 3 Hour/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: 25 marks	
	Total : 125 Marks	

Course Outcomes:	
After completion of the course students will be able to	
1.	To explain the need of process instrumentation and process control in chemical industries.
2.	To describe various chemical analysis instruments.
3.	To explain conductometry, turbidimetry and refractometry.
4.	To describe chromatoghraphy methods.
5.	To develop an ability to use theorems to compute the Laplace transform, inverse Laplace transforms. To calculate the transfer functions for first order and second order systems.
6.	To explain various control action for first order and second order system.

Topics covered		
UNIT-I	**Introduction**: Basic Concepts and characteristics of measurement system, various elements of instrument, performance characteristics. **Temperature measurement**: Introduction, methods of temperature measurement by expansion thermometers, filled system thermometers, electrical temperature instruments, pyrometers. Calibration of Thermometers **Level measurement**: Displacers, ultrasonic, microwaves, laser light.	**(06 Hours)**
UNIT-II	**Introduction to instrumental methods of analysis**: General Introduction, classification of instrumental methods, spectroscopy, properties of electromagnetic radiation, **pH metry, Karl Fischer Titration.** **Visible Spectrophotometry & Colorimetry**: Deviation from Beer's law, instrumentation applications. Molar compositions of complexes, examples.	**(06 Hours)**
UNIT-III	**Conductometry**: Introduction, laws, conductance, measurements, types of conductometric titrations, applications, advantages and disadvantages. **Nephelometry and Turbidimetry**: Introduction, theory, comparison with spectrophotometry, instrumentation, applications. **Refractometry:** Introduction, Abbe refractometer, instrumentation, applications.	**(06 Hours)**

UNIT-IV	**Chromatography**: Introduction, types, theoretical principles, theories of chromatography, development of chromatography, qualitative and quantitative analysis, applications and numerical. **Gas Chromatography**: Introduction, principles of gas chromatography, gas liquid chromatography, instrumentation, evaluation, retention volume, resolution. Branches of gas chromatography, applications and numerical. **High Performance (Pressure) Liquid Chromatography**: Introduction, principles, instrumentation, apparatus & materials, column efficiency and selectivity, applications. **GC-MS, LC-MS.**	**(06 Hours)**
UNIT-V	**Process dynamics:** Introduction, tools of dynamics analysis, ideal forcing function, input output model, transfer function models, proportion of transfer function, poles & zeros of transfer function with qualitative response, dynamic behavior of pure integrator, pure gain, first order & second order systems (with or without dead time), physical example of these systems.	**(06 Hours)**
UNIT-VI	**Introduction to feedback control:** Final Control Elements - Valve characteristics. Instrumentation symbols. Introduction to Process Flow Diagram (PFD) and Piping & Instrumentation Diagram (P&ID). **Control theory basics:** The control loops, process control terms, components of control loops, basic control action i.e. on-off, P, I, D, PI, PD, PID for 1st order process control loops and 2nd order response.	**(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 characteristics of On-Off Controller.
2.	Calibration of Bimetallic thermometer.
3.	Gas Chromatography.
4.	High Performance Liquid Chromatography.
5.	UV Spectrophotometer.
6.	Dynamic behavior of non interacting system.
7.	Dynamic behavior of interacting system.
8.	Mercury Thermometer With well and Without Well.
9.	Conductivity meter.
10.	PH meter analysis.
11.	Manometer Tuning.
12.	To Study the Thermocouple.
13.	Calibration of RTD.

Assignments:

1.	Students have to visit chemical industry and prepare a detailed report on various instruments used for process variable measurement.
2.	Students have to visit chemical industry and prepare a detailed report on various instruments used

	for chemical analysis.
3.	Watch NPTEL video and make report on various instruments used for process variable measurement.
4.	Presentation on instruments used for process variable measurement.
5.	Group discussions on instruments used for process variable measurement.
6.	To find Transfer Function for 1st order and 2nd order Instrument or process.
7.	Draw the Control Loop for HE for different process variable control.
8.	Draw the Control Loop for Batch Reactor for different process variable control.
9.	Draw the Control Loop for CSTR for different process variable control.
Text Books/References:	
1	S.K.Singh, "Industrial Instrumentation & Control", Tata McGraw Hill publishing company ltd, New Delhi, 2000
2	D. Pastranabis, "Principals of industrial instrumentation", 2nd edition, Tata McGraw 4 Hill publishing company ltd, New Delhi, 2003
3	Eckman D.P. "Industrial Instrumentation", Willey Eastern Ltd, New Delhi, 1984.
4	A.C. Shrivastav "Techniques in Instrumentation", New Delhi, 1984.
5	W.Boltan, "Instrumentation and Process Measurement", Orient Longman Ltd, Hyderabad, 1st Edition, 1993.
6	Willard H.H, "Instrumental methods of analysis", 6th Edition, CBS Publication New Delhi 1986
7	Galen W. Ewing, "Instrumental Methods of Chemical Analysis", 5th Edition, McGraw Hill Book Company, Singapore, 1990
8	D. A. Skoog, "Principal of Instrumental Analysis", Southern Collage Publication, Japan 1984
9	G. R. Chatwal, S.K. Anand, "Instrumental method of chemical analysis", 5th Edition, Himalaya Publishing House, Mumbai 2002.
10	Ray Choudhuri and Ray Choudhuri "Process Instrumentation, Dynamics and control for Engineers", 1st Edition, Asian Books Pvt Ltd, New Delhi, 2003.
11	B.G. Liptak, "Instrument Engineers Handbook" , 4th Edition , CRC Press, 2005.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I , II, III
Unit Test -II	UNIT – IV, V, VI

COMPUTER PROGRAMMING FOR CHEMICAL ENGINEERING - II

Designation: Computing

Course Pre-requisites:

Students should have basic knowledge of

1	Computer fundamentals
2	Computer Programming for Chemical Engineering-I

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Practical : 2 Hour /Week	Term work / practical : 50 Marks	Practical : 01
		Total credits : 01

Course Outcomes:

After completion of the course students will be able to

1.	Apply the knowledge of constant, variables, data types and various standard input output functions to write C-programs.
2.	Prepare a flow chart and write C-programs using control constructs and looping statements.
3.	Explain the concept of single dimensional and multidimensional arrays and write C-programs for single dimensional arrays, multidimensional arrays.
4.	Write C-programs using string.
5.	Explain the concept of pointer and write C-programs using pointers.
6.	Apply the knowledge of C-programming language, CHEMCAD, MATLAB for chemical engineering calculations.

Term Work:

Term work will consist of the programs/practicals listed below, out of which any eight programs/practicals are to be performed in laboratory by the students.

- **C-Programming Language:** Introduction, Character sets, constant, variables and Data Types: integer, float, double, char, string. Operators: arithmetic, relational, logical, increment and decrement, assignment, conditional. Standard input-output functions: printf ( ), scanf ( ), getch ( ) or getchar( ).

  1. Programs based on standard input-output functions used in C-Programming.

- Control statements: programs using if statement, if-else statement, goto statement and switch-case statement.

  2. Programs based on if-else statements.
  3. Programs based on goto statements.
  4.Programs based on switch-case statements.

- Loop statements: programs using while loop, do-while loop and for loop.

  5. Programs based on while loop.
  6. Programs based on do-while loop.
  7. Programs based on for loop.
  8. Programs to solve chemical engineering problems.

- Arrays: single dimensional and multi-dimensional arrays.

	9. Programs based on single dimensional arrays. 10. Programs based on multi-dimensional arrays.
➢	String: programs using string. String functions: strlen( )/ strcpy( )/ strrev( )/ strcat ( )/strlwr ( )/ strupr ( )/ strcmp ( ). 11. Programs based on strings and string functions. 12. Programs based on string functions.
➢	Pointers: programs using pointers. Use of * and & operators. Pointer arithmetic's. Use of pointers Pointer and function: parameter passing to function by reference and by value. File handling, Linked list 13. Programs based on pointers and function
➢	Application of C-programming language, CHEMCAD and MATLAB for Chemical Engineering: various calculations and solutions in Chemical Engineering. Term work includes programs based on following unit operations 13. Design of co-current and counter current heat exchanger 14. Design of Distillation column 15. Design of Mixed Flow Reactor 16. Design of Evaporator etc.
In addition to these above stated programs / practicals concern faculty member may design his/her own programs / practicals.	
Text Books/References:	
1.	Kanetkar, Y.C.; Let Us C, 4th revisededition, BPB Publications
2.	Cooper, M.; The Spirit of 'C' – An introduction to modern programming, Jaico Publisher
3.	Rajaraman, V.; Fundamentals of Computers, Prentice Hall of India
4.	Balagurusamy, E.; Programming in ANSY C, 2ndEdition, McGraw Hill Publication
5.	Sanders, D. H.; Computers Today, McGraw Hill Publications