BharatiVidyapeeth University
College of Engineering
Department of Chemical Engineering

Semester III

Total Duration : 28Hours/week
Total Credits :25
Total Marks : 750

Sr. No.	Subject	Teaching Scheme (Hours/week)				Examination Scheme (Marks)							Credit
		L	P/D	T	Total	End SemesterExamination	Continuous Assessment			TW/ O	TW/ P	Total	
							Unit Test	Assign-ments	Atten-dance				
1	Chemical Engineering Thermodynamics I	3	-	1	**4**	60	20	10	10	-	-	**100**	**4**
2	Strength of Material	3	2	-	**5**	60	20	10	10	-	25	**125**	**4**
3	Physical Chemistry	3	2	-	**5**	60	20	10	10	**-**	50	**150**	**4**
4	Chemical Process Calculations	3	-	1	**4**	60	20	10	10	25	-	**125**	**4**
5	Mechanical Operation	4	2	-	**6**	60	20	10	10	-	50	**150**	**5**
6	Professional Skill Development-III	4	-	-	**4**	60	-	40	-	-	-	**100**	**4**
Total		**20**	**6**	**2**	**28**	**360**	**100**	**90**	**50**	**25**	**125**	**750**	**25**

BharatiVidyapeeth University
College of Engineering
Department of Chemical Engineering

Semester IV

Total Duration : 28Hours/week
Total Credits :25
Total Marks : 750

Sr. No.	Subject	Teaching Scheme (Hours/week)				Examination Scheme (Marks)							Credit
		L	P/D	T	Total	End SemesterExamination	Continuous Assessment			TW/ O	TW/ P	Total	
							Unit Test	Assign-ments	Atten-dance				
7	Engineering Mathematics III	3	-	1	**4**	60	20	10	10	-	-	**100**	**4**
8	Fluid Flow Operations	4	2	-	**6**	60	20	10	10	**-**	50	**150**	**5**
9	Process Heat Transfer	4	2	-	**6**	60	20	10	10	-	50	**150**	**5**
10	Chemical Engineering Thermodynamics II	3	-	1	**4**	60	20	10	10	25	-	**125**	**4**
11	Chemical Process Industries	2	-	1	**3**	60	20	10	10	25	**-**	**125**	**3**
12	Professional Skill Development-IV	4	-	-	**4**	60	-	40	-	-	-	**100**	**4**
Total		**21**	**6**	**1**	**27**	**360**	**100**	**90**	**50**	**50**	**100**	**750**	**25**

BHARATI VIDYAPEETH

DEEMED UNIVERSITY, PUNE

B.Tech (Chemical) - 2014 Course

Semester-III

CHEMICAL ENGINEERING THERMODYNAMICS-I					
Designation: Professional Core					
Course Pre-requisites:					
Students should have knowledge of					
1.	Mathematics				
2.	Physics				
3	Chemistry				
TEACHING SCHEME:		**EXAMINATION SCHEME:**		**CREDITS ALLOTTED:**	
Lectures	: 3 **Hours/Week**	End Semester Examination	: 60 Marks	Theory	: 03
Tutorial	: 1 Hour /Week	Unit Test	: 20 marks	Tutorial	: 01
Total	: 4 **Hours/Week**	Continuous Assessment	: 20 Marks	Total credits	: 04
		Term Work/Oral	: 25 Marks		
		Total	: 125 Marks		
Course Outcomes:					
After completion of the course students will be able to					
1.	(a) Estimate energy requirement for a system				
2.	(a) Understand second law of thermodynamics and the concept of entropy (b) Calculate efficiency of heat engines and refrigerator, and calculate change in entropy for ideal gas.				
3.	(a) Understand P-T and P-V diagrams for pure fluids (b) Select appropriate equation of state for representing P-V-T behavior of gases and/or liquids.				
4.	(a) Calculate changes in internal energy, enthalpy, and entropy for ideal gases, and also for non- ideal gases through use of residual properties (b) Understand the criterion of phase equilibrium for a pure substance and use it to relate the enthalpy of phase change to the saturation pressure curve via Clausius- Clapeyron equation				
5.	(a) Understand refrigeration and liquefaction cycles.				
6.	(a) Estimate deviation from ideality for real gaseous mixtures and liquid solutions				
Topics covered					
UNIT - I	**First Law of Thermodynamics** Preliminary concepts of thermodynamics; Statement of first law of thermodynamics; Joules experiment and internal energy; Mathematical form of first law of thermodynamics; State function and path function; Intensive and extensive properties; Enthalpy; Steady state steady flow process; Equilibrium; Phase rule; Reversible and irreversible processes; Constant volume and constant pressure processes.				**(08 Hours)**

UNIT - II	**Second Law of Thermodynamics:** Necessity of second law of thermodynamics; Statements of second law of thermodynamics; Heat engine: Carnot approach; Kelvin-Plank statements; Thermodynamic temperature scale; Thermodynamic temperature and the ideal gas scale; Entropy: Clausius approach; Entropy change of ideal gas; Mathematical statement of second law of thermodynamics; Third law of thermodynamics and its mathematical statement	**(08 Hours)**
UNIT - III	**Volumetric Properties of Pure Fluids** PVT behavior of pure substance; Basic equation of state; Difference between Ideal gas and real gas; Equation governing PVT behavior of ideal gas; Development of thermodynamic relations for ideal gas for isochoric, isobaric, isothermal, adiabatic, and polytropic processes; Equations governing PVT behavior of real gas: (i) the viral equations, (ii) two parameter equations (van der Waal, and RedlichKwong equations), (iii) compressibility factor: two parameter theorem of corresponding state and three parameter theorem of corresponding state.	**(08 Hours)**
UNIT - IV	**Thermodynamic properties of Fluids:** Property relations for homogeneous phases: (i) Thermodynamic relations derived from laws of thermodynamics, Helmholtz energy, and Gibbs energy, (ii) Maxwell relationships; Two-phase systems: Clausius - Clapeyron equation and Antoine equation; Thermodynamic diagrams: (i) temperature-entropy, (ii) pressure-enthalpy, and (iii) enthalpy-entropy (the Mollier diagram).	**(08 Hours)**
UNIT - V	**Refrigeration and Liquefaction** The Carnot Cycle; The vapor- compression cycle; Comparison of refrigeration cycle; The Choice of refrigerant; Absorption refrigeration and power cycle; Organic Rankine cycle; Liquefaction processes	**(08 Hours)**
UNIT - VI	**Solution Thermodynamics** Fundamental property relation; Phase equilibrium using volumetric properties; Partial molal properties; Ideal gas mixtures and ideal solutions; Concept of fugacity and activity; Concept of residual and excess properties.	**(08 Hours)**

Tutorials:	
Tutorials will be based on the theoretical and/or numerical covered in six units	
1	Solving numerical in connection with the basic principles of thermodynamics
2	Questions involving first law applied to pure component systems.
3	Solving numerical in connection with entropy changes of ideal gas for various thermodynamic processes.
4	Draw P-T and P-V diagrams for pure substances.
5	Solving numerical based on application of thermodynamics to transient open and closed systems
6	Numerical involving Pure Fluid Properties Coupled to 1st and 2nd Laws.

7	Conducting surprise MCQ test for students
8	Solving numerical based on Refrigeration and Liquefaction.
9	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.
10	Students have to study any five NPTEL videos related to Chemical Engineering Thermodynamics I and prepare/present power point presentation.
11	Group discussions on any of the following topics: a) Importance of Chemical Engineering Thermodynamics in chemical industries. b) Practical applications involving various thermodynamic processes. c) Ideal Gas, Real Gas, Ideal gas mixture, Ideal solution.
12	Preparation of a brief report on applicability of equations of states (EOS) in chemical engineering systems.
13	Solve question papers of CET I of previous THREE years.
14	Unsolved numerical from the reference books on various topics studied
Text Books/ References:	
1.	J. M. Smith and H. C. Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw-Hill Publication
2.	T. E. Daubert, " Chemical Engineering Thermodynamics", McGraw- Hill Publication
3.	B. F. Dodge, "Chemical Engineering Thermodynamics", McGraw- Hill Publication
4.	S. I. Sandler, "Chemical Engineering Thermodynamics", McGraw- Hill Publication
Syllabus for Unit Test:	
Unit Test - I	UNIT– I, II, and III
Unit Test - II	UNIT– IV, V, and VI

STRENGTH OF MATERIAL

Designation: Breath

Course Pre-requisites:

Students should have

1.	Basic knowledge of Engineering Mechanics

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 3Hours/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/Practicalal : 25 Marks	
	Total : 125 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	Calculate stresses due to axial force.
2.	Calculate shear force and bending moment in the beam.
3.	Calculate deflection and bending stress in the beam.
4.	Calculate shear stress due to shear force and torsion.
5.	Calculate critical load for column.
6.	Calculate principal stresses.

Topics covered

UNIT-I	**Concept of stress and strain:** Normal, lateral, shear and volumetric stresses and strains, Stress-strain curve; Elastic constants and their inter relationship; Generalized Hooke's law; **Stresses due to Axial Load and Temperature:** Axial force diagram; Stresses, strains and deformation of determinate and indeterminate bars of prismatic, homogenous and composite cross section.	**(06 Hours)**
UNIT-II	**Shear Force and Bending Moment in Beams:** Concept of Shear Force and Bending Moment; Relation between Shear Force, Bending Moment and intensity of loading; Shear Force Diagram and Bending Moment Diagram of determinate beams due to concentrated load, uniformly distributed load, uniformly varying load and moments.	**(06 Hours)**
UNIT-III	**Deflection of Beams:** Concept of relation between deflection, slope, bending moment, shear force and intensity of loading; Macaulay's method, Elastic curve. **Flexural Stresses:** Theory and assumptions of pure bending; Moment of resistance; Flexure formula; Flexural rigidity; Modulus of rupture; Flexural stress distribution diagram for various sections; Force resisted by partial cross section.	**(08 Hours)**
UNIT-IV	**Shear Stresses:**Concept of direct and transverse shear; Shear stress formula; concept of complementary shear stress; Shear stress distribution diagram for symmetrical and unsymmetrical section. **Torsion of Circular Shafts:** Theory, assumptions and derivation of torsional formula; Shear stress distribution across cross section; Twisting moment diagram; Shear	**(06 Hours)**

	stresses and strains in determinate and indeterminate shafts of hollow, solid, homogeneous and composite cross sections subjected to twisting moment; Torsional rigidity.	
UNIT-V	**Combined Axial and Bending Stress:** Concept; Resultant stress due to the axial load and uni-axial or biaxial bending; Core of section. **Axially Loaded Long Columns:** Concept of critical load and buckling; Differential equation of elastic curve; Euler's formula for hinged ends; Equivalent length for different end conditions; Limitation of Euler's formula; Rankine's formula.	**(06 Hours)**
UNIT-VI	**Principal Stresses and Principal Planes:** Normal and shear stresses on any oblique plane. Concept of principal stresses and principal planes. Maximum shear stress; Analytical and graphical method. (Mohr's circle method); Combined effect of axial force, bending moment, shear force and torsion.	**(06 Hours)**

Text Books/References:

1.	R. C. Hibbeler, “Mechanics of Materials”, Pearson Prentice Hall,
2.	Rajput R. K., “Strength of Materials”, S. Chand Publication
3.	Punmia B. C., Jain, Ashok Kr. Jain Arun Kr., “Mechanics of Materials”, Laxmi Publication.
4.	Ramamrutham S. & Narayan R., “Strength of Materials”, DhanpatRai Publishing Co.
5.	Beer F..P. and Johnston E.R., “Mechanics of Materials”, McGraw Hill Publication
6.	GereJ.M. & Timoshenko S.P., “Mechanics of Materials”, CBS Publishers & Distributors
7.	Singer F. L. &Pytel A., “Strength of Materials”, Harper and Row Publication
8	Popov E. P., “Engineering Mechanics of Solids”, Prentice Hall of India (P) Ltd.
9	Singer F. L. &Pytel A., “Strength of Materials”, Harper and Row Publication

Syllabus for Unit Test:

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

PHYSICAL CHEMISTRY		
Designation: Basic science		
Course Pre-requisites: Basic knowledge for chemistry		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 03 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
Practical : 02 Hours /Week	Unit Test : 20 Marks	Practical : 01
Total : 05 Hours/Week	Continuous Assessment : 20 Marks	Total credits : 04
	Term Work/Practical : 50 Marks	
	Total : 150 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	Explain the basic concepts of bond forming and reactivity.
2.	Describe the principles and applications of spectroscopic techniques such as infra-red UV/Visible absorption spectrometry.
3.	Demonstrate the principles and functions of the UV and IR spectroscopy for chemical investigations.
4.	Recognize the use of catalysts for industrially important processes.
5.	Comprehend Structure-Property Relationship.
6.	Interpret concept of Surface and Interfacial Chemistry.

Topics covered

UNIT-I	**Bonding and reactivity:** Aromaticity-conditions necessary for delocalization of electrons, resonance structures stability rules, resonance in phenol, aniline, benzaldehyde, nitrobenzene molecules, Effect of inductive effect and resonance on pKa and pKb values of acids and bases. Reaction intermediates –carbonations, carban ions, free radicals and their stability. Types of reagents, types of reactions.	**(06 Hours)**
UNIT-II	**Reaction mechanisms:** Substitution at saturated carbon (SN1, SN2)- mechanism, factors favoring. Electrophilic aromatic substitution in benzene and mono substituted benzenes, activating and deactivating groups , nitration, Friedal-Craft reactions, sulphonation, diazotization. Nucleophilic substitution on on carbonyl carbon. Addition of HX on C=C 1, 2-Eliminations- E1mechanism, E 2, (Saytzeff, Hoffman products), factors favoring. Rearrangements- Beckman, Claisen, Reformatsky.	**(06Hours)**
UNIT-III	**Instrumental methods of chemical analysis:** UV-Visible spectroscopy: Lambert-Beer law, λ max, calculation of λ max for olefinic and cyclic structures, instrumentation, interpretation of spectra, applications. IR Spectroscopy: Introduction, instrumentation (double beam spectrophotometer) characteristic absorption in functional and finger print regions, interpretation of spectra, applications.	**(06 Hours)**
UNIT-IV	**Catalysis:** Introduction, types of catalyst, criteria or Characteristics of catalyst, adsorption theory of catalysis, catalytic promoters or activators, catalytic poisons, Enzyme catalysis, Applications of catalysts for industrially important processes.	**(06 Hours)**
UNIT-V	**Structure –Property Relationship:** Molecular interactions and bonds weaker than covalent bonds, e.g. hydrogen bond,dipole interaction,VDW forces etc.and there effects on various properties	**(06 Hours)**

	such as refractive index ,viscosity, surface tension, density, thermal conductivity, specific heat, diffusivity, melting point, boiling point, vapor pressure, heat of formation, latent of diffusion and vaporization, non ideal behavior in solutions, group contribution methods for estimation of these properties(including those of polymers and polymeric solutions).	
UNIT-VI	**Surface and Interfacial Chemistry:** Concept of surface /interfacial energy and surface /interfacial tension, Thermodynamics of surfaces, Gibbs adsorption equation and isotherm, Curved surfaces-Young, Laplace, Kelvin and Thompson equations contact angel and wetting phenomena, adhesion, cohesion, surface active agents: types and applications, surfactant aggregates, emulsions and micro emulsions preparation, stability and application.	**(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.	Preparation of benzoic acid from benzamide.
2.	Preparation of aspirin from salicylic acid.
3.	Conductometric titration between strong acid and strong base.
4.	Determination of percentage purity of sodium Bicarbonate by gravimetry.
5.	Estimation of Cu++ ions by spectrophotometer/colorimeter.
6.	Purification of organic compounds by crystallization and sublimation.
7.	To determine the number of molecules of water of crystallization in $BaCl_2.2H_2O$ by heating.
8.	Volumetric estimation of aniline from the given solution.
9.	Volumetric estimation of acetone from the given solution.
10.	Determine viscosity of given liquids by Ostwald's viscometer.
11.	To determine ΔH, ΔG,ΔS of the reaction, $Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$
12	Preparation of tetramine copper (II) sulphate.
13	Preparation of potasiumtrioxalato aluminate.
14	Preparation of crystal of potash alum.
15	To determine the equivalent weight of the given metal (Zn or Mg) eudiometrically.

Assignments:

1	What is resonance effect? Draw resonating structure of aniline, phenol, phenoxide ion.
2	Nucleophilic substitution.
3	Conductometric titrations.
4	Industrial applications of catalysts.
5	Adsorption theory of catalysis.
6	Gibbs adsorption equation and isotherm

Reference Books

1	Instrumental methods of chemical analysis ----B.K.Sharma, Goel publ.)
2	Instrumental methods of chemical analysis ----Chatwal –Anand
3	Organic chemistry –I L Finar volume I and II
4	Engineering Chemistry ---S.S.Dara
5	Physical chemistry –P L Soni

6	Atkins P.W. and Paula., Physical Chemistry,.8thEdn.,Oxford University Press.
7	Inorganic chemistry ----Cotton, Wilkinson
8	Spectroscopy ---Kalsi
9	Vogels text book of quantitative chemical analysis. (5thEdn.)

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

CHEMICAL PROCESS CALCULATIONS

Designation: Professional Core

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
Tutorial : 1 Hour /Week	Unit Test : 20 Marks	Tutorial : 01
Total : 4 Hours/Week	Continuous Assessment : 20 Marks.	Total credits : 04
	Term Work/Oral : 25 Marks	
	Total : 125 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	Explain the concept of units and dimensions and solve the problems on basic chemical calculations.
2.	Describe the concept of material balance without chemical reactions and solve the problems involved in various unit operations.
3.	Explain the concept of material balance involving chemical reactions and solve the problems on unit processes carried out in chemical industry.
4.	Explain the concept of recycle, bypass, purge operations and solve problems based on humidification, recycle, bypass and purge operations.
5.	Interpret the concepts of energy balance and solve numerical based on them.
6.	Apply the knowledge of gross and net calorific values of fuel and solve the problems based on them.

Topics covered

UNIT-I	**Basic Chemical Calculations:** Units and dimensions for mass and energy calculation for solid, liquid and gas; Mole concept; Basic composition calculation for homogeneous, two phase and three phase systems,	**(08 Hours)**
UNIT-II	**Material balances without Chemical Reactions:** Generalized law of conservation of mass; Mass conservation without chemical reaction; Mass balance for unit operations encountered in chemical process industry : Distillation, extraction, evaporation, blending etc.	**(08 Hours)**
UNIT-III	**Material balances involving Chemical Reactions:** Generalization of law of conservation of mass involving chemical reaction and its simplification; Chemical equations and stoichiometry; Some basic concepts: conversion, yield, selectivity; Material balance for unit processesencountered in chemical process industry: nitration, esterification, acylation, sulfonation etc.	**(08 Hours)**
UNIT-IV	**Recycle, bypass and purge operations:** Necessity of recycle, bypass and purge streams; Basic calculations of recycle, bypass and purge streams for unit operations and unit processes. Industrial examples of recycling, bypassing and purging with complete mass balance viz. biofuel synthesis, food processing etc.; Humidification operation**.**	**(08 Hours)**
UNIT-V	**Energy Balance:** Basic concepts; heat capacity; Sensible heat and latent heat: Clausius-Clapeyron equation; standard heat of formation, combustion, reaction, Hess's law; General equation of energy balance; Energy balance approach and calculations for exothermic and endothermic reactions with industrial examples; Steam table and its utility; Utility	**(08 Hours)**

	energy balance calculations.	
UNIT-VI	**Fuels and Combustion:** Types of fuels: solid, liquid and gas; Calculations of energy content of fuel; Analysis of fuel; oxygen requirement and excessity; Adiabatic flame temperature calculations.	**(08 Hours)**

Term Work/ Tutorial:	
Term work includes numerical on the following topics.	
1.	Basic chemical calculations.
2.	Material balances without chemical reactions.
3.	Material balances involving chemical reactions.
4.	Recycle, bypass, purge and humidification operation.
5.	Energy balance.
6.	Fuels and combustion.
Assignment:	
1.	Mass and energy balance for any one of following unit operations for given system.
	a) Distillation
	b) Evaporation
	c) Extraction
	d) Crystallization
	e) Drying. etc
2.	Mass and energy balance for any one of following unit processes for given system. These assignment may include overall energy and/or mass balance or energy and/or mass balance over a given chemical process equipment.
	a) Nitration
	b) Esterification
	c) Acylation
	d) Fermentation
	e) Sulfonation etc.
3.	Students have to visit chemical industry and prepare a detailed report on various unit operations and unit processes used in industry.
4.	Measurement of calorific values of any two types of fuel.
5.	Group discussions on mass and energy balance for unit operations and unit processes carried out in chemical industry
6.	Solve last five years GATE question papers with reference to chemical process calculations.
7.	Students have to study any five NPTEL videos related to chemical process calculations and prepare/present power point presentation.
8.	Numericals based on above six units.
9.	Technical interview based on knowledge of chemical process calculations.
10	Prepare models for recycle, bypass and purge operations carried out in chemical industry.
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 unit operations which are newly introduced in the current year.
13.	Write a report on your visit to research and development laboratory of national/international repute.
In addition to these above stated assignments concern faculty member may design his/her won.	
Text Books/References:	
1.	Bhatt, B. I. and Vora, S. M.; Stoichiometry (SI Units), Third Edition, Tata McGraw Hill Publishers, New Delhi.
2.	Himmelblau, D. M.; Basic Principles and Calculations in Chemical Engineering, Prentice Hall Publications

3.	Hougen, O. A.; Watson, K. M. and Ragatz, R A; Chemical Processes Principles, Part-I, Material and Energy Balances, Asia Publishing House, Bombay
4.	Felder, R.M. andRousseau, R.W.; Elementary Principles of Chemical Processes, 3rd edition, WileyJohn& sons Publications
5.	Rudd, D.F.; Powers, G.J. and Sirola, J.F.; Process Synthesis, Prentice Hall Publications
6.	Shukla, S.D. and Pandey, G. N.; Chemical Engineering Calculations, Lion Press, Kanpur
7.	Ranz, W.E.; Describing Chemical Engineering Systems, McGraw Hill Publications.

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

MECHANICAL OPERATION		
Designation: Professional Core		
Course Pre-requisites: None		
TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 4 Hours/Week	End Semester Examination : 60 Marks	Theory : 04
Practical : 2 Hours /Week	Unit Test : 20 Marks	Practical : 01
Total : 6 Hours/Week	Continuous Assessment : 20 Marks	Total credits : 05
	Term Work/Practical : 50 Marks	
	Total : 150 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	Understand the concept of particle size measurement, distribution and analyze the performance of size reduction equipment.
2.	Understand the concept of solid storage and solid conveying.
3.	Understand the concept of mixing and Calculate the power requirement for agitator.
4.	Understand the concept of particle mechanics and sedimentation
5.	Understand the concepts of filtration.
6.	Understand the concept of separation of solids from fluids.

Topics covered

UNIT-I	**Properties of Solid and Size Reduction** **Properties of solid**:- Particle size and shape, Mixtures of particles, Cumulative and differential screen analysis, Determination of particle size, Screen effectiveness and capacity, Industrial screening equipments. **Size Reduction**:- Crushing efficiency, energy requirements calculations by using different crushing laws, Size reduction equipments: Primary crushers, secondary crushers, Intermediate & fine grinders, Ultra fine grinders, Cutting machines, open circuit & Closed circuit grinding.	**(08 Hours)**
UNIT-II	**Handling and Transport of Solids** **Storage of Solids**:- Bins, silos, hoppers, Janseen's equation, characteristics of Bulk solids. **Transport of Solids**:- Conveyors: Working principles, Construction, Advantages, Disadvantages and design calculation of Screw conveyors, Belt Conveyors, Chain & Flight conveyors, Bucket elevators, Pneumatic conveyors.	**(08Hours)**
UNIT-III	**Mixing and Agitation** Necessity of mixing & agitation in chemical industries, Mixers for pastes and plastic masses. Mixers for dry powders. Criteria for mixer effectiveness. Mixing index in blending granular solids. Rate of mixing. Types of equipment, Mixing characteristics, Power consumption, Mixing index calculations, Agitator selection.	**(08 Hours)**
UNIT-IV	**Sedimentation** Gravity settling method: Motion of particles in fluid, drag force, drag coefficients, effect of particle shape, Stock's law, hindered settling, Terminal velocity, sink and float method, differential settling. Batch sedimentation, equipments for sedimentation, Kynch theory of sedimentation, calculation of area and depth of batch thickeners and continuous thickeners.	**(08 Hours)**
UNIT-V	**Filtration** Filter media and filter aids, classification of filtration, pressure drop through filter cake, filter medium resistance, specific cake resistance, Continuous Filtration,	**(08 Hours)**

	Washing and dewatering of filter cakes, Centrifugal filtration. Selection of filtration equipment.	
UNIT-VI	**Separation of solids from fluids** Froth flotation, magnetic separator, scrubbers, fiber and fabric filter, and electrostatic precipitators. Mineral jig, cyclone separator, hydro cyclone types and centrifuges, centrifugal clarifier.	**(08 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 determine effectiveness of given set of standard screen.
2.	To determine energy consumption and crushing law constants for jaw crusher.
3.	To determine Critical speed of Ball mill & Average particle size of the product obtained in ball mill.
4.	To determine mixing Index of a mixture in Ribbon Blender. **OR** To determine mixing Index of mixture in Sigma Mixer.
5.	To determine filter medium resistance and cake resistance by using Vacuum Leaf filter.
6.	To determine filter medium resistance and cake resistance by using Plate & frame Filter Press **OR** by using centrifuge machine.
7.	To determine area of batch thickener by conducting batch sedimentation test.
8.	To determine separation efficiency by using froth flotation cell.
9.	To determine separation efficiency by using magnetic separator.
10.	To determine efficiency of Cyclone separator.
Assignments:	
1	Pilot scale solid-liquid fluidization: Expansion characteristics of solids
2	Estimate power consumption for homogeneous system
3	Industry related unit operation (ANY ONE INDUSTRY) detailing of it.
4	How does filtration fit into the water treatment process?
5	How Does Filtration clean water?
6	What types of filters are used for water treatment? Explain in brief
7	Explain hand pump water filter
8	How does sedimentation fit in to the waste water treatment process?
9	What zones are present in sedimentation basin?
10	How is sedimentation sludge disposed of?
11	What is surface loading rate explain in brief. The flow into clarifier is 3.2 MGD in tank 80 feet long and 40 feet wide. what is surface loading rate?
12	Recent trends in particle size technology.
13	Watch the NPTEL video on this subject of any TWO modules and summarize it
14	Solve numerical problems asked in previous THREE year question papers.
15	Solve questions asked on filtration in previous THREE year question papers.
16	If your particles are not spherical which equivalent particle size would be suitable to calculate for the purpose of filtration
17	What media are used in filters? What factors affect filter efficiency?
Text Books/References:	
1.	McCabe, W. L.; Smith, J. C. and Harriott, P.; Unit Operations of Chemical Engineering, 6th edition, McGraw Hill Publications.
2.	Coulson, J.M.; Richardson, J. F.;Backhurst, J. R.; Harker, J. H.; Chemical Engineering Volume 2, 6th edition, Pergamon Press.
3.	Badger W. L &Banchero J.T. “Introduction to Chemical Engineering”, McGraw Hill

4.	Foust A. S “Principles of Unit Operation”.
5.	George G. Brown, “Unit operations”, CBS publishers and distributors.

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

BHARATI VIDYAPEETH

DEEMED UNIVERSITY, PUNE

B.Tech (Chemical) - 2014 Course

SEMESTER-IV

ENGINEERING MATHEMATICS- III		
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 : 04
Tutorial : 1 Hour /Week	Unit Test : 20 Marks	Total credits : 04
Total : 4 Hours/Week	Continuous Assessment : 20 Marks	
	Total : 100 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	To develop an ability of mathematical modeling of systems using differential equations and ability to solve linear differential equations with constant coefficient
2.	To develop an ability to solve the Laplace, heat and wave equations for a variety of boundary conditions in domains of simple geometry and with simple boundary conditions; the techniques available will include, separation of variables
3.	To develop an ability to solve problems on Fourier sine and cosine transform
4.	To develop an ability to use theorems to compute the Laplace transform, inverse Laplace transforms
5.	To develop an ability to calculate the gradients and directional derivatives of functions of several variables
6.	To develop an ability to use Green's theorem to evaluate line integrals along simple closed contours on the plane

Topics covered

UNIT-I	**Linear Differential Equations** (**LDE**): Solution of nth order LDE with Constant Coefficients, Method of Variation of Parameters, Cauchy's & Legendre's DE, Solution of Simultaneous & Symmetric Simultaneous DE. Applications of LDE to chemical engineering problems and allied engineering.	**(08 Hours)**
UNIT-II	**Partial Differential Equations** (**PDE**)**:** Solution of Partial Differential Equations 1) $\frac{\partial u}{\partial t} = a^2 \frac{\partial^2 u}{\partial x^2}$, 2) $\frac{\partial^2 u}{\partial t^2} = a^2 \frac{\partial^2 u}{\partial x^2}$, 3) $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$	**(08 Hours)**

	By separating variables only. Applications of PDE to problems of Chemical and allied engineering.	
UNIT-III	**Fourier Transform (FT)**: Fourier Integral theorem. Sine & Cosine Integrals. Fourier Transform, Fourier Cosine Transform, Fourier Sine Transforms and their inverses. Finite FT, Application of FT to problems on one and two dimensional heat flow problems.	**(08 Hours)**
UNIT-IV	**Laplace Transform (LT)**: Definition of LT, Inverse LT. Properties & theorems. LT of standard functions. LT of some special functions viz. error, 1st order Bessel's, Periodic, Unit Step, Unit Impulse, ramp, jump, parabolic, Si(t) and Ei(t). Problems on finding LT & inverse LT. Applications of LT for solving ordinary differential equations, liquid level systems, consisting of single tank and two tanks in series (interacting and non-interacting systems), second order systems (damped vibrator).	**(08 Hours)**
UNIT-V	**Vector Differentiation:** Physical Interpretation of Vector Differentiation. Radial, Transverse, Tangential & Normal components of Velocity and Acceleration. Vector differential operator. Gradient, Divergence & Curl. Directional derivative. Vector identities. Irrotational&Solenoidal fields. Application of vector differentiation to chemical engineering.	**(08 Hours)**
UNIT-VI	**Vector Integration**: Line integral, Surface & Volume integrals. Work done, Green's Lemma, Gauss-Divergence and Stoke's Theorem, Applications of Vectors to problems in Fluid Mechanics, Continuity equations, Stream lines, Equations of motion, Bernoulli's equation.	**(08 Hours)**

Assignments:	
1	Linear differential equation with constants coefficients.
2	Application of LDE and partial differential equations.
3	Fourier transform and inverse fourier a function which is neither even nor odd ,for even and odd function
4	Laplace transform and invese laplace transform and its application to differential equation
5	Vector identities and application of vector differential in mechanics.
6	line integral, surface integral and volume integral.

Text Books/References:	
1.	Advanced Engineering Mathematics by Peter V. O'Neil (Cengage Learning).
2.	Advanced Engineering Mathematics by Erwin Kreyszig (Wiley Eastern Ltd.)
3.	Engineering Mathematics by B.V. Raman (Tata McGraw-Hill).
4.	Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).
5.	Advanced Engineering Mathematics, Wylie C.R. & Barrett L.C. (McGraw-Hill, Inc.)
6.	Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).
7.	Applied Mathematics (Volumes I and II) by P. N. Wartikar& J. N. Wartikar (Pune VidyarthiGrihaPrakashan, Pune).
8.	Advanced Engineering Mathematics with MATLAB, 2e, by Thomas L. Harman, James Dabney and Norman Richert (Brooks/Cole, Thomson Learning).

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

FLUID FLOW OPERATIONS			
Designation: Professional Core			
Course Pre-requisites:			
Students should have knowledge of			
1.	Physics, Engineering Science and Engineering Mechanics.		
2.	Elements of Civil Engineering		
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 : 6 Hours/Week		Continuous Assessment : 20 Marks.	Total credits : 05
		Term Work/Practical : 50 Marks	
		Total : 150 Marks	
Course Outcomes:			
After completion of the course students will be able to			
1.	Describe the various properties of fluids and basic concept of fluid flow.		
2.	Apply the basic equations of fluid flow like Continuity and Bernoulli's equation for solving numerical in fluid flow operations.		
3.	Apply the basics of turbulent flow and flow measuring devices for solving numerical in fluid flow operations		
4.	Identify and explain the various types of energy losses for fluid flowing through a pipe.		
5.	Identify and select various types of fluid moving equipments for fluid flow		
6.	Explain the construction and working of fluidized bed reactor.		
Topics covered			
UNIT - I	**Basic Concepts of Fluid Flow:** Types of fluid: Newtonian and Non-Newtonian fluids; Properties of fluids; Concept of viscosity, calculation and measurement; Models for non-Newtonian fluids; Types of flow: laminar, transition and turbulent and their characteristics; Concept of fluid pressure, pressure measurement and calculation.		**(08 Hours)**
UNIT - II	**Equations of Fluid Flow:** Basic equations of fluid flow; Equation of continuity and motion (cartesian, cylindrical and spherical coordinates) in laminar flow and its applications for calculation of velocity profiles, shear stress distribution, volumetric flow rate, power etc. in engineering applications; Flow of incompressible fluids.		**(08 Hours)**
UNIT - III	**Turbulent Flow:** Basics of turbulent flow; Equations of continuity and motion for turbulent flows: Reynolds averaging, Boussinesq hypothesis, Prandtl mixing length theory, Turbulent models; Flow measurement: flow measuring devices; Velocity profile;		**(08 Hours)**
UNIT - IV	**Pressure Drop Calculation and Measurement in Pipe Flow:** Darcy-Weisbach equation; Bernoulli's equation; Friction factor: laminar, transition and turbulent flow; Models available to predict friction factor; Friction factor: valves, bends, fittings, sudden expansion and contraction, sudden obstruction etc.; Equivalent diameter concept for energy losses.		**(08 Hours)**

UNIT - V	**Flow Moving Equipments:** Pumps: Types; Selection and specifications; characteristic curves; cavitation phenomena; Net positive suction head (NPSH) calculations; System and operating parameters affecting pump performance; Calculation of power requirement.Blowers and compressor: Selection and specifications; Factors affecting performance; Power calculations for given duty.	**(08 Hours)**
UNIT - VI	**Flow Through Solids:** Expansion characteristics of solids: Drag and drag coefficient (C_D) , terminal settling velocity, settling in presence of other particles; voidage-superficial fluid velocity relationship, C_D VsN_{Re}; Boundary layer separation; Pressure drop calculation and measurement: skin and form friction, effect of system, operating and geometrical parameters, Ergun equation, experimental methods of measuring pressure drop. Applications of fluidization: catalytic cracking, chromatographic separation etc.	**(08 Hours)**

Term Work:

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

1.	To determine kinematic viscosity and to study the effect of temperature on kinematic viscosity of given oil.
2.	To study flow characteristics using Reynolds apparatus and determine Reynolds number.
3.	To determine the coefficient of discharge for venturimeter.
4.	To determine the coefficient of discharge for orificemeter.
5.	To determine Darcy Weisbach coefficient of friction of laminar and turbulent flow for given pipe.
6.	To determine friction and pressure drop for flow through helical/spiral coils.
7.	To find losses due to sudden expansion and contraction in pipe.
8.	To calculate minimum fluidization velocity using fluidized bed reactor.
9.	To verify Bernoulli's theorem.
10.	To study characteristics of centrifugal pump.
11.	To Study Darcy's law.
12.	To study pressure drop in packed bed for different fluid velocities.
13.	To determine the coefficient of discharge for different notches like rectangular notch, 45^0 V notch, 60^0 V notch and trapezoidal notch.
14.	To determine terminal velocity of particles in fluids of different viscosity and plot a graph of drag coefficient (C_D) as a function of $N_{Re.}$

Assignments:

1.	Numericals based on above six units.
2.	Visit to suppliers and prepare a report on detailed specifications of following fluid moving equipments.
	a) Pumps.
	b) Blowers.
	c) Compressors.
3.	Visit to suppliers and prepare a report on detailed specifications of following flow measuring devices.
	a) Venturimeter.
	b) Orificemeter.
	c) Pitot tube.
	d) Roatameters.
4.	Students have to study any five NPTEL videos related to fluid flow operations and prepare/present power point presentation.

5.	Students have to visit chemical industry and make a detailed report on overall fluid flow operations.
6.	Group discussions on any one of the following topics.
	a) Importance of fluid flow operations in chemical industries.
	b) Pumps, blowers and compressors.
	c) Flow measuring devices.
7.	Prepare models for various types of valves and write industrial applications.
8.	Prepare models for various types of bends and write industrial applications.
9.	Prepare models for various types of fittings and write industrial applications.
10.	Prepare a report on fluid flow operations which are newly introduced in the current year.
11.	Solve last five years GATE question papers with reference to fluid flow operations subject.
12.	Write a report on your visit to research and development laboratory of national/international repute.
13.	Technical interview based on knowledge of fluid flow operations.
14.	With the help of this subject knowledge, write a report on how you would apply your concepts in industry.
In addition to these above stated assignments concern faculty member may design his/her won.	
Text Books/ References:	
1.	McCabe, W. L.; Smith, J. C. and Harriott, P.; Unit Operations of Chemical Engineering, 5th edition, McGraw Hill Publications.
2.	Coulson, J.M.; Richardson, J. F.; Backhurst, J. R.; Harker, J. H.; Chemical Engineering Volume 1, 6th edition, Pergamon Press.
3.	Gupta, S.K.; Momentum transfer operations, Tata McGraw Hill Publishers.
4.	Bansal, R. K.; A text book of fluid mechanics and hydraulic machines, Laxmi Publications (P) Ltd, New Delhi.
5.	Bird, R.B.; Stewart, W.E.; Lightfoot, E.N.; Transport Phenomena, John Wiley & Sons, New York.
6.	Denn, M.M.; Process fluid mechanics, Prentice Hall Publications.
Syllabus for Unit Test:	
Unit Test - I	UNIT– I, II, III
Unit Test - II	UNIT– IV, V, VI

PROCESS HEAT TRANSFER		
Designation: Professional Core		
Course Pre-requisites:		
Students should have		
Basic knowledge of units and dimensions, mathematical concepts like differential and integral etc, fluid flow concepts like continuity equation, momentum balance.		
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 : 6 Hours/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.	Evaluate heat loss through pipe insulation, critical and optimum thickness for insulation.
2.	Identify the importance of dimensional analysis and derive the dimensionless numbers.
3.	Calculate the heat transfer coefficient and heat transfer rate for vertical, horizontal plate in case of film-wise condensation.
4.	Apply appropriate empirical correlations to estimate critical heat flux in boiling.
5.	Explain the evaporation phenomena and estimate economy of the evaporator.
6.	Compute heat transfer rates in case of conduction, convection and radiation.

Topics covered

UNIT-I	**Heat conduction** Thermal conductivity: solids, liquids, and gases; Generalized equation for heat conduction; Steady state heat conduction through: plane slab, composite slab, hollow cylinder, composite cylinder and hollow sphere; Heat loss through pipe: maximum loss, critical and optimum thickness of insulation; its application for the calculation of temperature profile, maximum temperature rise or drop, heat flow at surface; Heat transfer through extended surfaces of uniform cross section.	**(08 Hours)**
UNIT-II	**Convection without phase change** Basic concepts of convection; Natural and forced convection; Dimensional analysis: dimensionless groups and their physical significance; Film coefficients; Factors affecting film coefficient; Fouling resistance; Empirical equations for convection heat transfer in turbulent flow through tubes, through annulus and over a flat plate; Steady state convection heat transfer equation to calculate temperature distribution in laminar and turbulent flows.	**(08 Hours)**
UNIT-III	**Convection with phase change** Condensation basic concepts; Dropwise and filmwise condensation; Condensation on surfaces-Nusselt's theory: vertical surface, horizontal surface, and inclined surface. Boiling types; Effect of physical properties; Pool boiling curve; Correlations used in boiling; Concept of critical heat flux.	**(08 Hours)**
UNIT-IV	**Radiation** Basic concepts; Thermal radiation; Black body radiation; Properties and laws of radiation; The radiation shape factor; Laws of shape factor; Various cases of radiation between two surfaces; Radiation shields; Radiant heat exchange in an enclosure having black surfaces.	**(08 Hours)**
UNIT-V	**Evaporation**	**(08 Hours)**

	Introduction; Types of evaporators; Material and energy balance; Boiling point elevation; Capacity and economy; Multiple effect evaporators.	
UNIT-VI	**Unsteady state processes** Unsteady state heat conduction: infinite slab, infinite cylinder, sphere. Heat transfer in agitated vessels: calculation of film coefficient in coil, jacket; heating and cooling times; Application to batch reactor and processes.	**(08 Hours)**

Assignments	
1.	Write a report on the recent advances in heat 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 heat transfer equipment.
4.	Prepare a report on heat 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 capacity and economy for any industrial evaporator.
7.	Estimate how much heat transfer rate is decreased due to the scale formation on surface of industrial heat transfer equipment?
8.	By determining optimum thickness of insulation give solution to an industrial problem to minimize the heat loss.
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 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 heat transfer subject.
13.	Group discussion on the recent advances in heat transfer processes.
14.	Write a report on your visit to research and development laboratory of national/international repute.
15.	Technical interview based on the knowledge of heat 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 determine rate of heat flow and thermal conductivity of an insulating material.
2.	To determine thermal conductivity of a metal bar.
3.	To study Newton's law of cooling to find rate of heat flow.
4	To determine the local heat transfer coefficients using the various correlations in natural convection.
5.	To determine heat transfer coefficient in forced convection.
6.	To study film wise condensation.
7.	To study drop wise condensation.
8.	To determine the critical heat flux
9.	To study Stefan-Boltzman law and find the value of its constant.
10.	To study evaporators.
11.	To determine emissivity of an aluminum plate.
12.	To study unsteady state processes.

Text Books/References:	
1.	McCabe, W. L., J. Smith, and Harriot: "Unit operations of chemical engineering," Tata McGraw Hill.
2.	Kern, D. Q.: "Process Heat Transfer," 11th ed., Tata McGraw Hill Publication, New Delhi.
3.	Sukhatme, S. P.: "A Textbook on Heat Transfer,",4th ed., Universities Press, India, 2005.
4.	Richardson, J. F., and J. M. Coulson: "Chemical Engineering," Butterworth Heinemann, Volume 1.
5.	Holman,J.P.: "Heat Transfer," 9th ed., Tata McGraw Hill Publications, New Delhi,2004.

6.	Frank, K., M. Bohn: "Principles of Heat Transfer," 5th edition, PWS Publishing company, Boston, 1997.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL PROCESS INDUSTRIES

Designation: Professional Core

Course Pre-requisites: None

TEACHING SCHEME:	**EXAMINATION SCHEME:**	**CREDITS ALLOTTED:**
Lectures : 02 Hours/Week	End Semester Examination : 60 Marks	Theory : 03
Tutorial : 01 Hours /Week	Unit Test : 20 Marks	Total credits : 03
Total : 03 Hours/Week	Continuous Assessment : 20 Marks	
	Term Work/Oral : 50Marks	
	Total : 150 Marks	

Course Outcomes:

After completion of the course students will be able to

1.	Understand the concept of Unit operation and Unit processes as well the significance of process flow diagram.
2.	Understand the manufacturing processes for soda ash, caustic and chlorine and Indian scenario of chlor-alkali industries.
3.	Understand manufacturing processes of sulfur and nitrogen industry
4.	Understand nitration of hydrocarbons and typical industrial process for nitration
5.	Understand sulfonation and sulfation process used in organic industry
6.	Understand processes for various petrochemicals

Topics covered

UNIT-I	**Concept of Unit Operation and Unit process:** Unit operations and unit processes, Concept of block diagram, process flow diagram (ASME guidelines). Water for the chemical process industry and its treatment: Boiler feed-water, Cooling tower water, Process Plant water.	**(08 Hours)**
UNIT-II	**Chlor -alkali industries:** current status (Indian and global), Production and consumption pattern, Different processes for the manufacture of Soda ash, Caustic and chlorine	**(08Hours)**
UNIT-III	**Sulfur Industry:** Current status (Indian and global), Production and consumption pattern Sulfur and Manufacture of sulfuric acid, Different processes and comparison. **Nitrogen Industry:** Current status (Indian and global), Production and consumption pattern Ammonia, Nitric acid, Urea and other nitrogen fertilizers, Mixed fertilizers.	**(08 Hours)**
UNIT-IV	**Nitration:** Nitrating Agents, Kinetics and Mechanism of Aromatic Nitration, Nitration of Paraffinic hydrocarbons, Liquid phase nitration, Nitro compounds, and Commercial nitration process.	**(08 Hours)**
UNIT-V	**Sulfonation and Sulfation:** Sulfonating and sulfating agents and their principal applications, Sulfonation and Sulfation of aliphatic compounds, Sulfonation of aromatic compounds, Commercial sulfonation process.	**(08 Hours)**
UNIT-VI	**Petrochemicals:** Production of petrochemical precursors - olefins and aromatics, Production of ethylene, propylene, formaldehyde, methanol, ethylene oxide, ethanolamine, cumene, ethylene glycol, ethyl benzene	**(08 Hours)**

List of Practicals:

The practical shall include at least (6) assignments from the various units mentioned in the syllabus.

One industrial visit should be arranged to the process industry and students should prepare the report on the same as a part of the term work.	
Expert Interaction: Lecture(s) by eminent scholar(s) on the topic(s) mentioned in the syllabus.	
Assignments:	
1	One industrial visit should be arranged to the process industry and the students will prepare the report which includes the consumption pattern of the products produced, process flow diagram and process description, major engineering problems in the industry.
2	Students should prepare the plant-layout for the industry visited.
3	Students should visit one CETP (Central effluent Treatment Plant) nearby and prepare the report which includes different unit operations in CETP, Significance of each unit.
4	Students should visit one STP (Sewage treatment plant) and prepare the report which includes different unit operations in STP, block diagram.
5	Students should compile the list of vendors (manufacturers of pumps, contact, and address) along with the details like type, specifications, and costs and should prepare the comparative for the same.
6	Students should prepare the report on "Material of construction" for pumps for special applications using the data from assignment 4.
7	Students should make a report on "Indian scenario of inorganic industries" which will include the name of industries (from different chemical zones), products manufactured, and production capacity.
8	Students should make a report on "Fertilizer industries in Maharashtra and Gujarat" which will include the name of industries (from different chemical zones), products manufactured, and production capacity.
9	Model making of any one Unit operation used in chemical process industry.
10	Describe the different equipment used to run the process plant with different utilities.
11	Students should compile the list of Boiler manufacturers, contacts, and address along with their product range specifications.
12	Students should compile the list of vendors providing "water treatment plants" in chemical process industries along with their product specifications.
13	Give a presentation on "commercial aspects of petrochemical products".
14	AutoCAD drawing of process flow diagram for any one process from the syllabus
Text Books	
1.	Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M.Gopal Rao and Sittig .M) East West Press. ,New Delhi,3 rd Edition(1997).
2.	Austin G. T » Shreve's Chemical Process Industries", 5th ed., McGraw Hill.(1984)
3.	Groggins, Unit process in organic synthesis, Tata McGraw-Hill Education
Reference Books	
1	Faith, W. L., Keyes, D. B. and Clark, R. L., "Industrial Chemicals" John Wiley.(1975).
2	Kirk and Othmer, "Encyclopaedia of Chemical Technology" Wiley (2004).
3	Pandey G.N &Shukla.S.D, "Chemical Technology Vol - I" Vikas publication.
Syllabus for Unit Test:	
Unit Test -I	UNIT – I ,II,III
Unit Test -II	UNIT – IV,V,VI

CHEMICAL ENGINEERING THERMODYNAMICS-II

Designation: Professional Core

Course Pre-requisites:

Students should have knowledge of

1.	Chemical Engineering Thermodynamics I
2.	Mathematics
3	Chemistry, Physics

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

Course Outcomes:

After completion of the course students will be able to

1.	a) Understand the concept of fugacity and its application to gaseous and liquid systems b) Understand residual and excess properties to demarcate non- ideality in gaseous phase and liquid solution
2.	a) Understand criteria of phase equilibrium and stability b) Make typical phase equilibrium calculations pertaining to VLE, LLE, SLE, SVE, etc.
3.	a) Perform bubble P, dew P, bubble T, and dew T calculations for VLE b) Carry out thermodynamic consistency test for experimental VLE data
4.	a) Understand the criterion for chemical reaction equilibrium b) Establish relation of equilibrium constant to composition for gas phase and liquid phase reactions.
5.	a) Calculate equilibrium constant for heterogeneous system b) Understand phase rule for reacting system and its physical significance
6.	Understand thermodynamics of liquid-liquid equilibrium.

Topics covered

UNIT - I	**Solution Thermodynamics:** Concept of chemical potential; chemical potential as a criterion of phase equilibria; Concept of non ideality in gaseous mixtures; Fugacity and fugacity coefficient for species in solution; Methods of determination of fugacity coefficient; Concept of non-ideality in liquid mixtures; Activity and	**(06 Hours)**

	activity coefficient for species in solution; Excess properties; Gibbs excess energy; Model for estimation of excess property; Property change of mixing and heat effects in mixing.	
UNIT - II	**Phase Equilibria:** Criteria of phase equilibrium; Criterion of stability; Phase equilibria in single and multi component system; Phase rule: Duhems theorm; LLE, VLLE, SLE, and SVE; Phase diagrams; Dilute solution laws: Nernst's law, osmotic equilibrium.	**(06 Hours)**
UNIT - III	**Vapor-liquid equilibrium (VLE):** Qualitative behavior of VLE; Basic equation for vapor- liquid equilibrium; Liquid phase properties from VLE data; VLE at low to moderate pressures: excess Gibbs free energy models; Azeotropic data; VLE at high pressures; Multicomponent vapor- liquid equilibria; Bubble point and dew point calculations; Thermodynamic consistency test for VLE data.	**(06 Hours)**
UNIT - IV	**Chemical reaction equilibria:** The reaction coordinate; Application of equilibrium criteria to chemical reactions; The standard Gibbs energy change and the equilibrium constant; Effect of temperature on the equilibrium constant; Evaluation of equilibrium constant; Relation of equilibrium constants to composition; Phase rule for reacting systems; Multi-reaction equilibria.	**(06 Hours)**
UNIT - V	**Heterogeneous reaction equilibrium:** Notable industrial heterogeneous systems and thermodynamic role; The Gibbs energy change and equilibrium constant; Estimation of equilibrium constant for heterogeneous system by defining standard state of the phases involved; Pressure of decomposition; Simultaneous reactions; Combined physical and chemical equilibria.	**(06 Hours)**
UNIT - VI	**Liquid-liquid Equilibria (LLE):**	**(06 Hours)**

	Quantitative behavior of LLE; Basic equation governing LLE; Distribution coefficient (Partition Coefficient); Activity coefficient and its determination; Selection of extractant; Solubility parameters and estimation.	

Tutorials/Assignments:	
1	Questions involving fugacity and activity for the species in solution.
2	Solving numerical in connection with phase equilibria.
3	Solving numerical based on application of Roult's law for the calculation of dew point and bubble point
4	Conducting surprise MCQ test for students.
5	Draw P-xy and T-xy diagrams.
6	Solving numerical based on chemical reaction equilibrium.
7	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.
8	Students have to study any five NPTEL videos related to Chemical Engineering Thermodynamics I and prepare/present power point presentation.
9	Group discussions on any of the following topics: a) Importance of Phase equilibria in chemical industries. b) Thermodynamic properties for pure species and species in solution
10	Preparation of a brief report on applicability of liquid-liquid equilibrium (LLE) in chemical engineering systems.
11	Solve question papers of CET II of previous THREE years.
12	Unsolved numerical from the reference books on various topics studied.

Term Work:

Term work includes minimum 08 assignments/problems on each unit covered

Text Books/ References:

1.	J. M. Smith and H. C. Van Ness, "Introduction to Chemical Engineering Thermodynamics", McGraw- Hill Publication
2.	T. E. Daubert, " Chemical Engineering Thermodynamics", McGraw- Hill Publication
3.	K.V. Narayanan," Chemical Engineering Thermodynamics", PHI Learning Pvt. Ltd.
4.	B. F. Dodge, "Chemical Engineering Thermodynamics", McGraw- Hill Publication

5.	M. D. Koretsky, “Engineering and Chemical Thermodynamics”, 2nd Edition, John Wiley & Sons
6.	S. I. Sandler, “Chemical Engineering Thermodynamics”, McGraw- Hill Publication
7.	S. Glasstone, “Thermodynamics for Chemists”, Affileated East West Press Pvt.Ltd.

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