FACULTY OF ENGINEERING

Syllabus for the

S.E (Chemical Engineering)

(w.e.f June 2013)

UNIVERSITY OF PUNE

University of Pune
Structure for SE Chemical Engineering- 2012 Course

Subject Code	Subject	Teaching scheme			Examination Scheme					Marks
		Lect	Pr	Tut/ Draw	Online	Theory	Pr	Or	Tw	Total
TERM – I										
209341	Chemistry- I	4	2	--	50	50	50	--	--	150
209342	Introduction to Chemical Engineering	1	--	2	--	--	--	--	25	25
209343	Chemical Engineering Fluid Mechanics	3	2	--	50	50	--	50	25	175
209344	Chemical Engineering Materials	3	2	--	50	50	--	50	--	150
209345	Process Calculations	4	--	--	50	50	--	--	--	100
209346	Soft Skills	--	2	--	--	--	--	--	25	25
207004	Engineering Mathematics –III	4	--	1	50	50	--	--	25	125
	Total	**19**	**08**	**03**	**250**	**250**	**50**	**100**	**100**	**750**
TERM – II										
Subject Code	**Subject**	**Teaching scheme**			**Examination Scheme**					**Marks**
		Lect	**Pr**	**Tut/ Draw**	**Online**	**Theory**	**Pr**	**Or**	**Tw**	**Total**
209348	Chemistry - II	4	2	--	50	50	50	--	--	150
209349	Heat Transfer	4	2	--	50	50	50	--	--	150
209350	Principles of Design	4	--	2	50	50	--	--	50	150
209351	Chemical Engineering Thermodynamics I	4	--	--	50	50	--	--	--	100
209352	Mechanical Operations	4	2	--	50	50	50	--	25	175
209353	Workshop Practice	--	2	--	--	--	--	--	25	25
	Industrial Training I (to be evaluated in fifth semester)	--	--	--	--	--	--	--	--	--
	Total	**20**	**08**		**250**	**250**	**150**	**--**	**100**	**750**

Note: - **This syllabus is subject to change without prior notice by the concerned BOS**

SEMESTER I

209341: CHEMISTRY-I

Teaching scheme:
Lectures: 4 Hrs / week
Practicals: 2 Hrs / week

Examination scheme:
Paper: Online-50 Marks,
Theory-50Maks
Practical: 50 Marks

Objectives:

1 .To impart the basic concepts of organic chemistry
2. To develop understanding about concepts on organic reactions for analysis of unit Processes
3. To study the different analytical instruments.

Unit -I Bonding and reactivity **08 lectures**

Covalent bonding- Introduction to VBT (revision). Molecular orbital theory, MO structures of s-s, s-p , p-p overlaps , molecular orbital structure of butadiene, benzene, MO energy diagrams for diatomic molecules H_2 , O_2 , CO. Aromaticity-conditions necessary for delocalization of electrons, resonance structures stability rules, resonance in phenol, aniline, ,benzaldehyde ,nitrobenzene molecules, Inductive effect and Resonance effect on pKa and pKb values of acids and bases. Reaction intermediates -carbonations, carbon ions, free radicals and their stability. Types of reagents, types of reactions.

Unit -II Kinetics and photochemistry **08 lectures**

Kinetics: Rate of reaction, rate constant, order of reaction, kinetics of first and second order reactions, numerical on above, Activated complex theory of reaction rates kinetics of complex reactions. Photochemistry: Introduction and importance, Stark-Einstein law, photochemical rate law, examples of photochemical reactions kinetics of i) H_2, Cl_2 reaction ii) dimerisation of anthracene.

Unit-III Instrumental methods of Analysis **08 lectures**

a) **Chromatography,**: Adsorption and partition principles, Study of TLC, column, HPLC, Gas Chromatography and their applications.
b) **Optical methods**: UV, Lambert-Beer law, λ_{max}, calculation of λ_{max} for olefinic and cyclic structures using Woodward Feiser rules, instrumentation IR spectroscopy-introduction, instrumentation and Interpretation of spectra, applications., Flame photometry- principle, instrumentation and applications

Unit-IV Solutions **08 lectures**

Solution :-definition, why substances dissolve, temperature and solubility, solution of gas in gas, gases in liquid, Henry's law, the ideal solution, Raoult'1s law of ideal solution, solutions of liquids in liquids, theory of dilute solution. Colligative properties, osmosis, osmotic pressure, Colligative properties of dilute solution- lowering of vapor pressure, elevation of boiling point and thermodynamic derivation, depression in freezing point and thermodynamic derivation. Abnormal behavior of solutions of electrolytes, van't Hoff factor. Numericals on all above.

Unit-V

Reaction mechanisms **08 lectures**

Substitution at saturated carbon (S_N1, S_N2) - mechanism, kinetics, stereochemistry, factors favoring it. Electrophonic aromatic substitution in benzene and mono substituted benzenes, activating and deactivating groups, nitration, Friedel-Craft reactions, sulphonation, and diazotization. Nucleophilic substitution on carbonyl carbon. Addition of HX on C=C, 1, 2-Eliminations- E_1 mechanism, E_2, (Saytzeff, Hoffman products), factors favoring it. Rearrangements- Beckmann, Claisen, Favorskii

Unit-VI

(a) Heterocyclic compounds **08 Lectures**

Aromaticity, preparation, reactions of pyrrole, furan, pyridine, quinoline.

(b) Dyes- Nomenclature, methods of application, color and chemical constitution (chromophore-auxochrome theory), classification of dyes on the basis of chemical structure, diazotization and coupling for azo dyes ,synthesis of crystal violet, alizarin, methyl orange, phenolphthalein

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Practicals (Total 10 experiments)

1 Diameter of solute molecule by viscosity measurements.
2 To determine rate constant of first order reaction of acid catalyzed hydrolysis of ester.
3 Preparation of benzoic acid from benzamide, crystallization and purity checking by TLC.
4 To determine molecular weight of solid by Elevation in B.P
5 Analysis of sample on HPLC/FTIR/GC
6 To find molecular wt. of solute by depression in freezing point of solvent
7 To determine Partition coefficient of iodine between water and CCl_4 and hence to determine the molecular condition of iodine
8 To estimate sodium ion concentration in solution by flame photometer
9 Colorimetric estimation of cobalt/ nickel ion in solution
10 Preparation of m-nitro aniline from m-dinitro benzene
11 Estimation of Cu^{++} ions by spectrophotometer
(Any six experiments from the above)
12 Identification of given organic compound (with maximum one functional group) by systematic analysis
(Minimum 4 compounds)

Note - Practical examination will be for three hours and students will perform TWO experiments (one organic analysis and one from remaining)

Reference Books

1. Organic chemistry -I L Finar volume I and II
2. Inorganic chemistry - J.D. Lee
3. Physical chemistry -P L Soni
4. Physical Chemistry- Atkins
5. Instrumental methods of chemical analysis ----Chatwal -Anand
6. Analytical chemistry- Skooge and West
7. Reaction mechanism - Jerry March

8. Reaction mechanism-Peter Sykes
9. Spectroscopy ---Kalsi
10. Heterocyclic chemistry-Acheson
11. Synthetic dyes-O.P. Agarwal

209342: INTRODUCTION TO CHEMICAL ENGINEERING

Teaching Scheme:
Theory: 1 hr/Week
TW: 2 hrs/Week

Examination Scheme:
TW: 25 Marks

Objectives:
1. To study the basic unit operations and unit processes in Chemical industry
2. To study the Process instrumentation and safety
3. To introduce the student with basic concepts of Chemical Engineering

Unit-I: INTRODUCTION: introduction to chemical engineering; history of chemical engineering and chemical technology; Scope of Chemical Engineering, Nature of Industries.

Unit-II: Basic Chemical Calculations: units and dimensions, conversion and conversion factors.
Basic Concepts: concept of mole, weight percent, mole percent, normality, molarity, molality, vapor pressure, partial pressure.

Unit-III: Unit Operations: Introduction, Definition, examples like Size reduction, sedimentation, filtration, Distillation, evaporation, absorption, extraction, fluid handling, fluid-solid contacting, fluid-solid separation, fluid storage, mixing, solid handling, crystallization, drying, leaching, size separation.

Unit-IV: Unit processes: introduction to unit processes with simple examples like sulphonation, polymerization, oxidation, hydrogenation, saponifoication, etherification, nitration, chlorination.

Unit-V: Basic concept of chemical processes: Conversion, Yield, efficiency, flow diagram, flow sheets, & block diagram, with examples.

Unit-VI: Process instrumentation and safety: Temperature scale, measurement of temperature using bimetallic thermometer, mercury expansion thermometer, gas filled thermometer. Pressure scales & units, measurement of pressure. Level measurement. Flow measurement. Measurement of viscosity. Personal protection devices.

Reference Books:

1. Unit operations in chemical engineering by W.L. McCabe and J.C. Smith and Peter Harriott, Mc Graw Hill 5th ed. 1993.
2. Himmelblau, D.H, Basic Principles and Calculations in Chemical Engineering, 5th Edn., Prentice Hall, New York, 1990.
3. Coulson J M and Richardson J F, Chemical Engineering, Vol. I and II, Pergamon Press, NY, 1990.
4. Badger and Banchero, Introduction to Chemical Engineering, 1st Edn., McGraw Hill, NewYork,1954.

TW: Based on the study of the Laboratory equipments. Minimum 8.

209343: CHEMICAL ENGINEERING FLUID MECHANICS

Teaching scheme:	**Examination scheme:**
Lecture: 3 hrs. /week	Paper: Online:50 Marks Theory: 50 Marks
Practical: 2 hrs. /week	TW: 25 Marks Oral: 50 marks

Objectives:

1. To introduce the basic concepts of fluid mechanics and their applications in Chemical Engineering.
2. To develop the ability to formulate problems, identify the basic mechanisms, and solve the problem by mathematical analysis or by application of experimental data.
3. To understand and use differential equations to determine pressure and velocity variations in internal and external flow.
4. Develop relationships among process or system variables using dimensional analysis.

UNIT 1: Introduction
Fluid, Properties of fluid, Classification of fluids, Newton's law of viscosity, Rheological classification of fluids, Pressure and temperature dependence, Types of flow, Lines to describe the flow, Application of fluid flow in Chemical Engineering. **06 Lectures**

UNIT 2: Fluid Statistics And Its Applications
Hydrostatic equilibrium, parametric equation, Hydrostatic equilibrium in centrifugal field; Concept of atmospheric, gauge and absolute pressure, manometers, pressure measurement by simple and differential manometer. **06 Lectures**

UNIT 3: Basic Equations Of Fluid Flow And Flow Measuring Devices
Basic equations of fluid flow: Continuity equation, equation of motion, Flow measurement using Venturimeter, Orificemeter, Rotameter & Pitot Tube, **04 Lectures**

UNIT 4: Flow of Incompressible Fluids In Conduits
Shear stress distribution, Relation between skin friction and wall shear, The friction factor; Laminar flow through circular pipe, on inclined plane, through annular space; Relation between average and maximum velocity, Major and Minor Loses, Darcy Weisbach equation, Friction factor chart. Numerical based on above. **08 Lectures**

UNIT 5: Boundary Layer and Dimensional Analysis
Concept of hydrodynamic boundary layer, Growth over a flat plate, Different thickness of boundary layer, Fundamental dimensions of quantities, Dimensional homogeneity, Dimensional analysis by Rayleigh's method and Buckingham's method, Dimensionless numbers. **06 Lectures**

UNIT 6: Flow Past Immersed Bodies And Transportation Of Fluids
Drag and drag coefficient, Flow through beds of solids, Motion of particles through fluids, Introduction to fluidization, Pipes and tubing's, Joints and fittings, Major and

minor losses, Different types of valves, Pumps: Centrifugal pump, Performance of centrifugal pumps. Numerical based on above. **08 Lectures**

Practicals

1. Determination of viscosity.
2. Reynolds experiment to determine laminar and turbulent flow.
3. Flow through packed bed
4. Flow through venturimeter
5. Flow through orifice meter
6. Flow through pipe fitting(Minor Losses)
7. Flow through Spiral Coil.
8. Flow Through Helical Coil
9. Determination of friction factor (Major Losses)
10. Verification of Darcy's law
11. Characteristics of centrifugal pump
12. Verification of stokes law
13. Calibration of rotameter
14. Verification Of Bernoulli theorem

Minimum 8 Practical from the above list should be performed

1. **Reference Books:**
2. McCabe, Smith, Hariot, "Unit Operations in Chemical Engineering" , 7th ed.,
3. M. Coulson, J.F. Richardson, with J.R. Backhurst and J.H. Harker, Coulson "Richardson Chemical Engineering, Volume-1" , 6th ed., Butterworth-Heinemann, 1999
4. R K Bansal, "A Textbook of Fluid Mechanics and Hydraulic Machines", 9th ed. Laxmi Publications, New Delhi, 2004
5. Modi, L.P., Seth, S.M., "Hydraulics and Fluid Mechanics", Standard Book House, New Delhi,2002
6. Bird R.B., Stewart W.E., Lightfoot E.N. "Transport phenomena" 2ed., Wiley Publications,2002

209344: CHEMICAL ENGINEERING MATERIALS

Teaching Scheme:
Lecture: 3 hr/ week
Practical: 2 hr/week

Examination Scheme:
Paper: Online:50 Marks
Theory: 50 Marks
Oral: 50 Marks

Objectives:

1. To impart the basic concepts of material science
2. To develop understanding about selection based on properties for various applications
3. To study the different methods for testing of materials
4. The applications of advance materials like nanomaterials

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1. Introduction:
Introduction to materials and their principle properties, Structure property relationships in materials. Introduction to determination of mechanical properties of materials ASTM methods. **4 Lect.**

2. Basic principles in selection of materials for fabrication and erection of chemical plant. Testing of materials, destructive and nondestructive tests, structure of atom and chemical bonds, crystal structures and their influence on material properties, Deformation and slip processes. **6 Lect.**

3. Metals and their alloys:
Iron – carbon diagram, Ferrous and nonferrous alloys, mild steel, special steels, stainless steels, brasses, aluminum alloys and titanium alloys, high and low temperature material, insulation, refractories.
Heat Treatments: Methods for fabrication, rolling, bending, central punching, riveting, and welding. **7 Lect.**

4. Nano materials: Classification, synthesis, characterization and application of Nano materials – Fullerenes, Bucky balls, carbon nano tubes, fullerites. Nano particles – silver nano particles. Applications of Nano materials in Chemical Industry**.** **6 Lect.**

5. Experimental techniques: Electron Microscopes; scanning electron microscopy (Basics, Principal Elements, working), transmission electron microscopy (Basics, Principal Elements, working). **Scanning probe microscopes;** scanning tunneling microscopy, atomic force microscopy, **other kinds of microscopes;** X-ray diffraction **7 Lect.**

6. Typical Engineering Materials: Definition of ceramics and glasses; interaction between structure, processing, and Mechanical, electrical and thermal properties of ceramic phase; Applications of ceramic and glass materials; Crystalline and non-crystalline ceramics, silicates, refractories, clays, cements, glass vitreous silica, and borosilicate**.** Ceramic Organic materials, Organic protective coatings. **6 Lect.**

Reference Books

1. James F. Shacketford, introduction to material science, McMillan publishing company, Newyork ISBN 1990.
2. D.Z. Jestrazebaski, properties of Engg. Materials, 3rd Ed. Toppers. Co. Ltd.
3. J.L. Lee and Evans, Selecting Engineering materials for chemical and process plants, Business Works 1978.
4. A text book of machine design, Khurmi R.S. and Gupta J.K.
5. Material Science & Metallurgy for Engineers, Dr.V.D.Kodgire, Everest Publishing House.
6. Introduction to Nano Technology, John Wiley & Sons by Charles P Poole, Frank J Owens.
7. Nano materials, synthesis, properties and applications, Institute of physics publishing, Bristol and Philadelphia, by A.S. Edels tein and R.C. Kamarhati

Practical:

1. Microstructure observation and study of metals and alloys. (Minimum five) low Carbon steel, medium carbon steel, high carbon Steel, tin, bronze, brass, phosphor Bronze.
2. Study of properties of polymeric materials; impact test and polymeric Tests. Synthesis of Polymers like nylon, PVC, PTFE etc
3. Different types of hardness test on metals. i.e. Rockwell hardness test, Brinell hardness test, Shore scleroscope tests.
4. Izod and Charpy impact test on mild steel, copper, brass and aluminum.
5. Chemical analysis of metals and alloys (Any one element to be analyzed e.g. Molybdenum from stainless steel, carbon from steel, copper from brass etc.
6. Macrostructure observation: (flow lines observation in forging by macro etching Sulphur printing of steel.)
7. Study experiments based in, i) Dye penetration ii) Rubber lining, iii) Ultrasonic test, iv) Heat treatments.
8. Study of Nanomaterials, Synthesis of Nanomaterials.
9. Study of Moisture Adsorption by Nanomaterials.
10. Study of Temperature V/S Relative Humidity for Nanomaterials.
11. To synthesize gold/silver (Au/Ag) nanoparticles and record the optical absorption spectra using simple absorption spectrometer.
12. To synthesize zinc oxide (ZnO) nanoparticles using a chemical route and calculate the size using UV-Vis absorption spectrum.
13. To synthesize titanium nanoparticles (TiO_2) using a chemical route and determine the phase and size using X-ray diffraction. (Using Scherrer formula).
14 To synthesize the Fe_2O_3 nanoparticles of different shapes and calculate the average size using scanning electron microscope (SEM) or transmission emission microscope (TEM).

*** Minimum 8 experiments to be performed from the above suggested experiments.**

209345: PROCESS CALCULATIONS

Teaching scheme:
Lectures: 4 Hrs / week

Examination scheme:
Paper: Online: 50 Marks
Theory: 50 Marks

Objectives:

1. To give students the basic knowledge of processes in Chemical engineering field
2. To study the basics required in calculations of material and energy requirements of any process
3. To understand the implications of steady and unsteady state processes
4. To understand the importance of material and energy balance calculations in industrial applications

Unit 1: Basic Chemical Calculations **4 lectures**

Introduction to unit processes and operations and their symbols, process flow sheet, Concept of steady and unsteady state operations, Dimensions and Units, Basic Chemical Calculations including mole, equivalent weights, solids, liquids, solutions and their properties, properties of gases.

Unit II: Material Balances without Chemical Reactions **8 lectures**

Concept, material balance calculations, recycling and bypassing operations, introduction to unsteady state processes with examples like batch reactor, accumulation of inert components, etc.

Unit III: Material Balances involving Chemical Reactions **9 lectures**

Concept, material balance calculations, electrochemical reactions, recycling and By-passing operations.

Unit IV: Energy Balances **7 lecture**

Concept, energy and Thermo chemistry, energy balances, heat capacity of pure substances and mixtures, latent heats, enthalpy of pure substances and mixtures, absolute enthalpy, heat of reaction, adiabatic reactions, thermo chemistry of mixing processes, dissolution, liquid-liquid mixtures, gas-liquid systems.

Unit V: Stoichiometry and Unit Operations **10 lectures**

Distillation, absorption and stripping, extraction and leaching, crystallization, psychrometry, drying, evaporation, introduction to stoichiometry and industrial problems.

Unit VI: Combustion **4 lectures**

Calorific values, coal, liquid fuels, gaseous fuels, air requirement and flue gases, combustion calculations.

Reference Books

1. Stoichiometry by Bhatt & Vora
2. Basic Principles & Calculations in Chemical Engineering by Himmelblau.
3. Chemical Process Priciples Part I by Hougen & Watson
4. Elementary Principles of Chemical Processes, Interactive Chemical Process Principles, 3Ed. By Richard M. Felder Ronald W. Rousseau

209346: SOFT SKILLS

Teaching Scheme:	**Examination Scheme:**
Practical: 2 hr/week	TW: 25 Marks

Objectives:

1. To identify the most critical issues that confronted particular periods and locations in history
2. To identify stages in the development of science and technology
3. To understand the purpose and process of communication
4. To produce documents reflecting different types of communication such as technical descriptions, proposals, and reports
5. To develop a positive attitude and self-confidence in the workplace and
6. To develop appropriate social and business ethics.

Professional speaking: Interview process, characteristic of job interview, pre-interview preparation techniques, frequently asked interview questions.

G.D – Nature of G.D, G.D and debate, importance of G.D, strategy of G.D, techniques for individual contribution, group interaction strategy.

Presentation skills– Nature and importance of oral presentation, planning the presentation, preparing the presentation, organizing your presentation, rehearsing and presentation. Improving delivery, checklist for making presentation.

Professional writing: Routine business letters – letter writing skills, form and structure, style and tone, enquiry letters, replies to enquiry letters, P.O, letters urging action, complaint and adjustment letters.

Sales letters – Sales letters, organizing sales letters, opening, body, closing.

Resume and job application – Writing resume, job application letters.

Business memo– Principles and fundamentals, business memo, letter versus memo, form and structure of memo, writing strategies, characteristics of effective memo.

E-mail messages- Principles and fundamentals, advantages of Email messages, characteristics successful Email messages.

Reports – Nature and significance, types of reports, format of reports, writing strategies.

Proposals – Nature and significance, type of proposal, structure of formal proposal, writing tips.

Technical articles– Nature and significance, types of technical articles, journal articles and conference paper, review and research articles, writing strategies.

Soft skills: What are soft skills? , global competition, hard skills (technical skills) versus soft skills, emotional intelligence, interpersonal skills, motivation, leadership skills, decision making, negotiation skills, business etiquette, problem solving skills, conflict management, stress management, crisis management, social understanding, behaviors traits, teamwork.

Human values: Morals, values, ethics, integrity, work ethics, virtues, respect for others, caring, sharing, honesty, courage, time management, cooperation, commitment, empathy, self confidence, challenges in work place, spirituality.

Engineering Ethics: Overview, senses of engineering ethics, variety of moral issues, types of enquiries, moral dilemma, moral autonomy, moral development, consensus

And controversy, profession, models of professional roles, responsibility, ethical theories, self control, self interest, customs, religion, self respect, overview of safety, responsibility and human rights, case study.

Global issues: Globalization, multinational corporations, environmental ethics, computer ethics, moral leadership, code of ethics.

Engineers as managers: Foresight as future managers in organizations, as consulting engineers, as experts, as advisors, as CEO's, Entrepreneurship skills.

Term Work:

Term work and theory are considered to be integral part of the course.

Term work shall consist of a journal consisting of regular assignments and presentations completed in the practical class and at home, the total number of assignments should not be less than twelve, generally covering the topics mentioned above. As far as possible, submission should be word processed on a computer using a standard package by the student himself.

For the purpose of assignments, extensive use of research papers published in technical journals and articles published in magazines and newspapers may be made so that there is no repetition by the individuals. Oral presentations exercises and group discussions should be conducted batch wise so that there is a closer interaction. Students should be sent to industrial visits for exposure to corporate environment.

Reference Books

1. Krishna Mohan and Neers Banarge (1996), Developing Communication Skills, Macmillan India Ltd.
2. Day (1995), How to write and publish a scientific paper, Cambridge Lowpriced Edition.
3. Bernice Hurst (1996) , Handbook of communication skill, 2nd Edition, Kogan page
4. Strunk W (Jr.) and White E.B., The elements of style, Latest edition, Macmillan Publishing Company, New York
5. University of Chicago Press Manual of Style, Publ. University of Chicago Press, (Chicago. Latest Edition).
6. M Ashraf Rizvi , Effective technical communication, Mc graw Hill
7. R.S. Naagarazan, Professional ethics and human values, New Age international Publishers.
8. Elizabeth Valuance, Business Ethics at work.

UNIVERSITY OF PUNE

For Chemical /Bio Tech/Printing Engineering (Sem I)
For Petroleum/Petrochemical/Polymer Engineering (Sem II)
207004 ENGINEERING MATHEMATICS – III (2012 Course)

Teaching Scheme:
Lectures – 4 Hrs./Week
Tutorials – 1 Hr./Week

Examination Scheme:
Paper – 50 Marks (2 Hrs.)
Online – 50 Marks
Term work: 25 Marks

Section I

Unit I: Linear Differential Equations (**LDE**) and Applications (09 Hours)
LDE of n^{th} order with constant coefficients, Method of variation of parameters, Cauchy's & Legendre's DE, Simultaneous & Symmetric simultaneous DE. Applications of LDE to chemical engineering problems and mass spring system.

Unit II: Fourier Transform (**FT**) (09 Hours):
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.

Unit III: Laplace Transform (**LT**) and Applications: (09 Hours)
Definition of LT, Inverse LT, Properties & theorems, LT of standard functions, LT of some special functions viz. error, First order Bessel's, Periodic, Unit Step, Unit Impulse, ramp, jump, parabolic, Si(t) and Ei(t).
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).

Section II

Unit IV: Vector Differential Calculus (09 Hours)
Physical interpretation of Vector differentiation. Radial, Transverse, Tangential & Normal components of velocity and acceleration. Vector differential operator, Gradient, Divergence & Curl, Directional derivative, Solenoidal, Irrotational and Conservative fields, Scalar potential, Vector identities.

Unit V: Vector Integral Calculus and Applications (09 Hours)
Line, Surface and Volume integrals, Work-done, Green's Lemma, Gauss's Divergence theorem, Stoke's theorem. Applications of vectors to problems in Fluid Mechanics, Continuity equations, Stream lines, Equations of motion, Bernoulli's equations.

Unit VI: Applications of Partial Differential Equations (**PDE**) (09 Hours)
Basic concepts, modeling of Vibrating string, Wave equation, one and two dimensional Heat flow equations, method of separation of variables, use of Fourier series. Applications of PDE to problems of Chemical and allied engineering.

Text Books:
1. Advanced Engineering Mathematics, 9e, by Erwin Kreyszig (Wiley India).
2. Advanced Engineering Mathematics, 7e, by Peter V. O'Neil (Cengage Learning).

Reference Books:
1. Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).
2. Advanced Engineering Mathematics, Wylie C.R. & Barrett L.C. (McGraw-Hill, Inc.)
3. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).
4. Applied Mathematics (Volumes I and II) by P. N. Wartikar & J. N. Wartikar (Pune Vidyarthi Griha Prakashan, Pune).
5. Higher Engineering Mathematics by B.V. Ramana (Tata McGraw-Hill).
6. Advanced Engineering Mathematics with MATLAB, 2e, by Thomas L. Harman, James Dabney and Norman Richert (Brooks/Cole, Thomson Learning).

Tutorial and Term Work:
i) Tutorial for the subject shall be engaged in minimum of four batches (batch size of 20 students maximum) per division.
ii) Term work shall consist of six assignments (one per each unit) based on performance and continuous internal assessment.

Mujumdar

SEMESTER II

209347: CHEMISTRY-II

Teaching Scheme:
Theory: 4 Hrs/Week
Practical: 2 hr/week

Examination Scheme:
Paper: Online:50 Marks
Theory: 50 Marks
Practical: 50 Marks

Objectives: To impart the basic concepts of physical and analytical chemistry

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Unit - I Biomolecules: **08 lectures**

Carbohydrate: Classification, reactions of glucose, D. L configuration, Cyclic structure of glucose, cellulose, starches. Cellulose acetate, nitrate, ether. Proteins-formation of peptide linkage, features of peptide linkage, alpha-helical configuration, beta-pleated structure, primary, secondary, tertiary, quaternary structures of proteins. Amino acids-alpha- amino acids, classification, properties and reactions. General introduction of cofactors and coenzymes, catalytic site of enzyme, factors affecting enzyme activity, classification of enzymes. Vitamins and hormones (in short)

Unit-II Transition metals and Co-ordination chemistry: **08 lectures**

Electronic configuration of first series transition metals, shapes of d- orbital characteristics (variable oxidation states, magnetic property, color of transition metal compounds). Ligands, C.N. and geometry , nomenclature of complexes, chelates . Theories of co-ordination- i) Werner ii) EAN iii) VBT for tetrahedral and octahedral complexes iv) CFT (including crystal field splitting in octahedral field and tetrahedral field, CFSE for octahedral complexes , applications of CFT)

Unit - III Volumetric analysis: **08lectures**

Standard solutions and their preparations, Concentration terms, calculation of equivalent weight in different reactions, types of titrations-neutralization (with titration curves), complexometric, redox and precipitation with examples. Theory of indicators in above titrations. Numericals on all above.

Unit –IV: **08 lectures**

(a) Adsorption: Introduction to Freundlich and Langmuir theories of adsorption (revision) ,adsorption from solution, B.E.T. Theory of adsorption of gases, ,activation energy, , numerical on above.

(b) Catalysis: characteristics, types, adsorption theory of catalysis, promoters, poisons, enzyme catalysis, industrial applications of catalysts;

i) Zeolites- structure, properties (adsorption, catalysis), applications as catalyst for reactions(amination of alcohol. NO_x pollution control, alkylation ,cracking conversion of methanol),
ii) Co-ordination catalysts- In Wacker process, carbonylation, photolysis of water
iii) Oxide catalysts- oxide surface structure, application of V_2O_5, $Fe_2(MoO_4)$ for oxidation.

Unit -V

Stereochemistry: 08 lecture

Basic concepts, conformation isomerism of ethane, propane, butane, cyclohexane, monosubstituted cyclohexane, optical isomerism with 1 and 2 chiral centres, AA, AB type, erythro, threo, meso diastereomerism, geometrical isomerism (compounds with one double bond)

Unit-VI 08 lectures

Unit processes in organic synthesis:

Mechanism, thermodynamics and kinetics of nitration, Halogenation, sulphonation and sulphation, nitrating, sulphonating and sulphating agents, egs- preparation of nitrobenzene, nitroacetanilide, preparation of chloral and vinyl chloride, preparation of dodecylbenzene sulphonate, preparation of lauryl alcohol and dimethyl ether.Details of equipment used in the Unit processes.

Practicals:

1. Adsorption of acetic acid on charcoal to verify Freundlich isotherm
2. Determination of purity of sod. Carbonate by titration method
3. Preparation of tris ethylene diammine nickel (II) thiosulphate
4. Preparation of tetramine copper (II) sulphate, pot. trioxalato aluminate
5. Preparation of osazone derivative of glucose
6. Estimation of glucose/acetone in solution
7. Oxidation of toluene to benzoic acid by oxidation with $KMnO_4$
8. Conversion of benzoic acid into its anilide derivative and its crystalisation
9. Purification of organic compounds by crystalisation and sublimation (one each)
10. Determination of chloride content by Mohrs method
11. Preparation of nitrobenzene
12. Sulphonation of benzene/toluene

(Any 10 experiments of the above)

Note - practical examination will be for three hours and students will perform TWO experiments

Reference Books:

1 Organic Chemistry- Finar vol 1 and 2
2 Organic Chemistry- Bahl and Bahl
3 Inorganic chemistry---J D Lee (ELBS)
4 Inorganic chemistry ----Cotton, Wilkinson
5 Instrumental methods of chemical analysis ----Chatwal -Anand
6 Analytical chemistry- Skooge and West
7 Physical Chemistry- Atkins
8 Physical Chemistry- Puri and Sharma
9 Stereochemistry - Elliel
10 Unit processes in organic synthesis- P.H. Groggins

209348: HEAT TRANSFER

Teaching scheme:
Lecture: 4 hrs. /week
Practical: 2hrs./ week

Examination scheme:
Online: 50 Marks
Theory:50 Marks
Practical: 50 marks

Objectives:
1. To impart the basic concepts of heat transport
2. To develop understanding about heat exchangers and evaporators

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Unit-I Basics concepts of heat transfer: **06 lectures**
The relation of heat transfer with thermodynamics, conduction heat transfer, convection heat transfer, radiation heat transfer, Thermal conductivity, thermal insulation, units and dimensions.

Unit-II Heat conduction: **08 lectures**
General differential equation of conduction, Steady state heat conduction through a plane slab, composite slab, hollow cylinder, composite cylinder and hollow sphere. Contact resistance, heat transfer between surfaces and surrounding, critical thickness of insulation. Heat transfer through extended surfaces of uniform cross section. Transient/Unsteady State Heat Conduction

Unit-III Convection heat transfer: **10 lectures**
Convection without phase change:
Natural and forced convection, principal heat balance equation in laminar flow Empirical equations for convection heat transfer in turbulent flow through tubes, through annulus and over a flat plate. Dimensional analysis, dimensional groups used in heat transfer
Convection with phase change:
Condensation: Modes and features, Nusselt's equation, condensation on vertical and horizontal plate Boiling: Pool boiling of saturated liquid, types of boiling, concept of critical heat flux

Unit-IV Radiation: **08 lectures**
Thermal radiation, black body radiation, properties of radiation, laws of radiation. The radiation shape factor, various cases of radiation between two surfaces, radiation shields

Unit-V Heat Exchangers: **08 lectures**
Basic types of heat exchangers, overall heat transfer coefficient, fouling factor. Double pipe heat exchanger design by LMTD and effectiveness-NTU methods calculations of overall heat transfer coefficient and area), Shell and tube heat exchangers

Unit-VI Evaporation: **06 lectures**
Introduction, types of evaporators, material and energy balance, boiling point elevation, capacity and economy, multiple effect evaporators

Practical: Minimum 8 Experiments to be performed.

1. Heat conduction
2. Unsteady State Heat Transfer
3. Natural convection
4. Forced Convection
5. Thermal radiation-determination of emissivity
6. Double pipe heat exchanger
7. Shell and tube heat exchanger
8. Plate Heat exchanger
9. Heat transfer in agitated vessels
10. Double effect evaporator
11. Open pan evaporator
12. Heat pipe demonstrator
13. Fluidized bed heat transfer

Reference Books:

1. J P Holman, "Heat Transfer" 9th edition, Tata McGraw Hill Publications, New Delhi (2004)
2. Frank Kreith, Mark Bohn, "Principles of Heat Transfer" 5th edition, PWS Publishing company, Boston (1997)
3. S. P. Sukhatme, "A Textbook on Heat Transfer", 4th ed, Universities Press (India),., 2005
4. D. Q. Kern, "Process Heat Transfer", 11th ed., Tata Mc Graw Hill Publication, New Delhi
5. Bird R.B., Stewart W.E., Lightfoot E.N. "Transport phenomena" 2ed., Wiley Publications,2002

209349 PRINCIPLES OF DESIGN

Teaching scheme:
Lecture: 3 hrs. /week
Drawing: 2 hrs. /week

Examination scheme:
Online: 50 Marks
Theory: 50 Marks
Term-work: 50 marks

Objectives:

1. To impart the basic concepts of chemical engineering drawing, mechanical design and process design of different unit operations
2. To develop understanding about drawing of shafts, coupling, bearings, keys belts etc.

Unit 1. Basic considerations in design:
Distinction between process design and process equipment design (mechanical design), Design Codes, Design working pressure and temperature, Design Loads, Concept of Stress, strain and modulus of elasticity, Factor of Safety, Young's Modulus,
Stress Concentration, Fatigue, Creep, Endurance Limit, Lateral strain and Poisson's Ratio, Stresses due to static and dynamic loads. Thermal stresses, Impact stresses, corrosion allowance, weld joint efficiency factor. **06 Lectures**

Unit2: Design Preliminaries:
Shear force and bending moment, deflection in beams, bending stress, torsional shear stress, stresses in struts (short, intermediate, and long), stresses in flat plates, Compound stresses and principal planes, theories of failure, elastic instability, membrane stresses in shells of revolution. . **06 Lectures**

Unit 3: Design of shafts, keys, and couplings:
Shafts: Types of shafts, Design of shafts under steady load, suddenly applied load and fluctuating loads, shafts subjected to combined loads, equivalent bending and twisting moments. ***Keys***: Types of keys, stresses developed in flat keys, shear and crushing design procedure. ***Couplings:*** Types of couplings, Design of sleeve, split muff, and flange coupling. . **06 Lectures**

Unit 4: **Design of joints, drives and bearings:**
Joints: Design of riveted and welded joints
Drives: Types of belts and belt drives, working Stresses in Belts, Velocity ratio, slip and creep of the belt, length of belt, ratio of driving tension, condition for transmission of maximum power. ***Bearings***: Types of bearings, design procedure for journal Bearing, dynamic load rating for rolling contact bearing, life of a bearing, reliability of a bearing.
. **08Lectures**

Unit 5: Design of thin-walled pressure vessels subjected to internal and external pressure:
Introduction to pressure vessels, types of pressure vessels, proportioning of pressure vessels, selection of L/D ratio, optimum proportions, codes and standards for
pressure vessels (IS: 2825; 1969), design stress, design criteria, design of shell (spherical and cylindrical), design of different types of heads and closures, design of flanges and nozzles, compensation for openings and branches.

Design of pressure vessels subjected to external pressure: design of shell, heads, stiffening rings as per IS: 2825; 1969. **08 Lectures**

Unit 6: Design of high Pressure Vessels (thick pressure vessels)- Materials of construction, stresses in thick cylinder, pre stressing of thick walled vessels, monoblock, multilayer, autofrettage, shrink fitted shell, ribbon and wire wound vessel, analysis and design of high pressure vessels including shell and head along with the stress distribution.
06 Lectures

Reference Books:

1. "Process equipment design" by L.E. Brownell and E. Young, John Wiley, New York, 1963.
2. "Introduction to Chemical Equipment Design" by B.C. Bhattacharya C.B.S. Publications.
3. "Process Equipment Design" by M.V. Joshi, Mcmillan India.
4. "Chemical Engineering Vol. 6" by J.M. Coulson, J.F. Richardson and R.K. Sinott, Pergamon Press.
5. "A Textbook of Machine Design", R S Khurmi & J K Gupta, Eurasia Publishing House

Term Work:

Term-work shall consist of minimum 08 assignments based on the above syllabus out of which 02 assignments should be performed (drawn) using AUTOCAD.

209350: CHEMICAL ENGINEERING THERMODYNAMICS-I

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Online: 50 Marks
Theory: 50 Marks

Objectives:

The students completing this course are expected to:

1. Be able to understand the basic thermodynamic terminology and scope, Thermodynamics laws and their applicability and limitations.
2. Select an appropriate equation of state for representing the P-V-T behavior of gases and/or liquids.
3. Calculate changes in U, H, S and G for ideal gases, and also for non-ideal gases through the use of residual properties and fugacity.
4. Understand the second law of thermodynamics and its limitations, various thermodynamic cycles, entropy concept, ideal engine efficiency.
5. Understand the criteria for chemical equilibrium and the variables needed to define any thermodynamic system completely.
6. Understand the working principle and performance of refrigerators and heat pumps.

Unit-I Introduction to chemical engineering thermodynamic and first law:
The scope of thermodynamics, fundamental and derived quantities, first law of thermodynamics: Formation of 1st law of thermodynamics, state and path functions, thermodynamic systems, steady state flow system, phase rule, reversible process heat capacity. **7 lectures**

Unit-II Volumetric properties of pure fluids: The P.V.T. behavior of pure substance, the viral equation, the ideal gas, the constant volume, constant pressure, adiabatic, polytrophic processes, real gas, applications of Viral equation, critical properties, Vander Wall equation, Benedict- Webb – Rubin equation, Redlich –Kwong equation. **8 lectures**

Unit-III Heat effects: sensible heat effects, temperature dependence of heat capacity, standard heat of reaction, standard heat of formation, standard heat of combustion, temperature dependence of ΔH^0, heat effects of industrial reactions. **3 lectures**

Unit-IV Second law of thermodynamics: Limitations of First Law, Statements of second law, analysis of Carnot cycle, ideal and actual engine efficiencies, various thermodynamic cycles, power cycles with external combustion or heat pump cycles, power cycles with internal combustion**,** Concept of entropy and derivation from second law, mathematical statement of 2nd law, statement of 3rd law. **9 lectures**

Unit-V Thermodynamic properties of Fluids: Fundamental property relations for closed systems, Maxwell relationships, residual properties, residual properties by equations of state, two-phase systems, Clausius- Clapeyron equation, type of thermodynamic diagram, availability. **8 lectures**

Unit-VI Refrigeration: Refrigeration cycle (p-v, t-s, h-s, and h-x diagrams) for vapor compression and Adsorption refrigeration systems, Evaluation of COP, duty and load of such cycles, heat pumps, liquefaction. **5 lectures**

Reference Books:

1) Introduction to Chemical Engineering Thermodynamics: J. M. Smith & H. C. Vanness
2) Principles of Chemical Equilibrium : Kenneth Denbigh
3) Chemical Engineering Thermodynamics : B. F. Dodge
4) Chemical Engineering Thermodynamics : T. E. Daubert
5) Thermodynamics for Chemists: Glasstone S.
6) Thermodynamics for Chemical Engineers: Weber and Meissner
7) Chemical and Process Thermodynamics: B. G. Kyle
8) Molecular Thermodynamic: Praunitz
9) Chemical Engineering Thermodynamics: Narayanan
10) Chemical Engineering thermodynamics: Y.V.C. Rao

209351: MECHANICAL OPERATIONS

Teaching scheme:
Lectures: 4 Hrs / week
Practicals: 2 Hrs / week

Examination scheme:
Paper: Online-50 Marks,
Theory-50Marks
Practical: 50 Marks
Term work: 25Marks

Objectives:

1. To study the properties of particles and the separation techniques used for different solid particles
2. To study the mixing and agitation of process fluid in a chemical industry using different mixers along with the mixing patterns and power requirement calculations
3. To understand fluid solid systems for slurry concentration using sedimentation, thickeners and clarifiers.
4. To learn different mechanical processes and operations in a chemical industry used for material processing.

Unit -I Separations of solid particles: 7 hrs

Particle size and shape, Mixtures of particles, Determination of particle size, Standard screen series, screen analysis, Screen effectiveness and capacity, Industrial screening equipments. Froth flotation, magnetic separator, scrubbers, fiber and fabric filter, and electrostatic precipitators. Mineral jig, cyclone separator, hydro cyclone types and centrifuges, centrifugal clarifier.

Unit -II Size reduction of solids: 8 hrs

Necessity of size reduction, working action of size reduction, Crushing efficiency, energy requirements calculations by using different crushing laws,
Classification of size reduction equipments: Primary crushers, secondary crushers, Intermediate & fine grinders, Ultra fine grinders, Cutting machines, Open circuit & Closed circuit grinding.

Unit -III Handling And Transport of Solids: 8 hrs

Storage of solids, characteristics of Bulk solids. Conveyors: Working principles, Construction, Advantages, Disadvantages and design calculation of Screw conveyors, Belt Conveyors, Chain & Flight conveyors, Bucket elevators, Pneumatic conveyors.

Unit -IV Mixing and Agitation: 5 hrs

Necessity of mixing & agitation in chemical industries, Types of Impellers & propellers, Different flow patterns in mixing, Calculation of power requirement of mixing equipment, Mixing equipment of pastes & viscous material, Solid – Solid Mixing, Agitator selection.

Unit -V Filtration: 6 hrs

Filter media and filter aids, classification of filtration, pressure drop through filter cake, filter medium resistance, specific cake resistance, Continuous Filtration, Washing and dewatering of filter cakes, Centrifugal filtration.

Unit -VI Fluid – Solid systems: 11 hrs

a. Motion of particles in liquid, drag force, drag coefficients

b. Gravity settling method: Terminal velocity, Stoke's law and Newton's law, free settling, sink and float method, differential settling.

c. Sedimentation and thickening: Batch sedimentation, equipments for sedimentation, Kynch theory of sedimentation, calculation of area and depth of continuous thickeners, batch thickeners, and continuous thickeners.

d. Fluidization: flow through packed beds, characteristics of fluidized systems, minimum fluidization velocity, types of fluidization, applications of fluidization

Reference Books

1. McCabe W. L. &Smith J.C. "Unit Operations in Chemical Engineering". McGraw Hill Publications.
2. Coulson J. M. & Richardson J.F. "Chemical Engineering Vol. 2", Pergamon Press.
3. Badger W. L & Banchero J.T. "Introduction to Chemical Engineering", McGraw Hill Publications.
4. Foust A. S "Principles of Unit Operation".
5. George G. Brown, "Unit operations", CBS publishers and distributors.

List of Practical

Minimum Eight numbers of Experiments to be performed for the term work out of the following list.

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 OR Average particle size of product obtained in Bhrustone 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 minimum fluidization Velocity & to verify Ergun's Equation.
9. To determine separation efficiency by using froth flotation cell.
10. To determine separation efficiency by using magnetic separator.
11. To determine efficiency of Cyclone separator.

Apart from the above industrial visit (at least one in a year) to any chemical industry is COMPULSORY. The students are required to prepare an industrial visit report (neatly typed and spiral bound) and submit to the department for the

purpose of TW assessment. TW is to be assessed based on practical performed and industrial visit. Out of 25 TW marks industrial visit carries 10 marks.

211353: WORKSHOP PRACTICE

Teaching Scheme:
Practical: 2 hr/week

Exam Scheme:
Term Work: 50 Marks

Topics to be covered at the time of practicals:

1. General purpose Machine Tools.
2. Joining Processes.
3. Pattern making and Foundry.

List of Practicals:

1. One job on lathe with taper turning thread cutting, drilling.
2. One job on lathe + milling machine – keyway cutting, gear cutting etc.
3. One job of welding.
4. One job of pattern making and foundry – one simple job of non- ferrous material.

A record of the work performed should be presented in the form of a journal based on topics under (A) and the jobs completed under practicals (B).

Reference Books:

Hajra Choudhary; Workshop Technology; Vol. I & II

INDUSTRIAL TRAINING- I

(To be evaluated in Fifth Semester)

Industrial training shall be as per norms of the institute. The list of industries where students can undergo training will be approved and published by the department. Period of training will be during vacation without affecting regular class work/examination. During the training, the student shall study/analyze the operation/process/design or the complete industry in detail. They shall submit a report in detail identifying the problems with their suggestion for solution and conclusions to the department through the faculty coordinator assigned for the same at the end of the training period. The minimum duration of industrial training is 1-2 weeks. A committee consisting of two faculty of the department will carry out assessment of the training. Students shall make a presentation before the committee.