Savitribai Phule Pune University

UG CHOICE BASED CREDIT SYSTEM

SYLLABUS

FOR

UNDER GRADUATE ROGRAMME IN SECOND YEAR CHEMICAL ENGINEERING

(2019 Course)

UNDER

FACULTY OF SCIENCE AND TECHNOLOGY

WITH EFFECTIVE FROM A.Y. 2020-21

Savitribai Phule Pune University, Pune

SE(Chemical) 2019 Course (With effect from Academic Year 2020-21) for Semester-III

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credits			
		Theory	Practical	Tutorial	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
207004	Engineering Mathematics-III	03	--	01	30	70	25	--	--	125	03	--	01	04
209341	Industrial Chemistry I	03	04	--	30	70	--	50	--	150	03	02	--	05
209342	Fluid Mechanics	03	02	--	30	70	25	--	25	150	03	01	--	04
209343	Engineering Materials	03	02	--	30	70	--	--	25	125	03	01	--	04
209344	Process Calculations	03	--	01	30	70	25	--	--	125	03	--	01	04
209345	Soft Skills	--	02	--	--	--	25	--	--	25	--	01	--	01
	Total	**15**	**10**	**02**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**05**	**02**	**22**
209346	Audit Course 3	--	MOOC Certificate Course in Chemical &Allied Engineering											

Savitribai Phule Pune University, Pune

SE(Chemical) 2019 Course (With effect from Academic Year 2020-21) for Semester-IV

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credits			
		Theory	Practical	Tutorial	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
209347	Industrial Chemistry II	03	04	--	30	70	--	50	--	150	03	02	--	05
209348	Heat Transfer	03	02	--	30	70	--	--	25	125	03	01	--	04
209349	Principles of Design	03	02	--	30	70	25		--	125	03	01	--	04
209350	Chemical Technology I	03	--	--	30	70	--	--	--	100	03	--	--	03
209351	Mechanical Operations	03	02	--	30	70	25	--	25	150	03	01	--	04
209352	Project Based Learning	--	04	--	--	--	50	--	--	50	--	02	--	02
	Total	**15**	**14**	**--**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**07**	**--**	**22**
209353	**Audit Course 4**	**--**	Online Course/Spoken Tutorial/NPTEL Certificate Course in Chemical & Allied Engineering											

Savitribai Phule Pune University, Pune
Second Year of Chemical /Bio Technology/Printing Engineering – Sem I (2019 Course)
Course Code: 207004, Course Name: Engineering Mathematics III

Teaching Scheme:	**Credit Scheme:**	**Examination Scheme:**	
Lectures: 3 Hrs./Week	Theory: 3	In-Sem Exam:	30 Marks
Tutorials: 1 Hr./Week	Tutorial: 1	End-Sem Exam:	70 Marks
		Term work:	25 Marks

Prerequisites: - Differential & Integral calculus, Linear Differential equations of first order and first degree, Collection, classification & representation of data, Permutations & combinations Fourier series and Vector algebra.

Course Objectives:
To make the students familiarize with concepts and techniques in Ordinary and Partial differential equations, Fourier transform, Laplace transform and Vector calculus. The aim is to equip them with the techniques to understand advanced level mathematics and its applications that would enhance analytical thinking power, useful in their disciplines.

Course Outcomes (CO's): At the end of this course, students will be able to

1) Solve higher order linear differential equations and its applications to engineering problems in their disciplines.
2) Apply Integral transform techniques such as Fourier transform & Laplace transform to solve differential equations involved in Vibration theory, Heat transfer, Liquid level systems and related engineering applications.
3) Apply Statistical methods like correlation & regression and probability theory as applicable to analyzing and interpreting experimental data in testing and quality control.
4) Perform vector differentiation & integration, analyze the vector fields and apply to fluid flow problems.
5) Solve Partial differential equations such as wave equation, one and two dimensional heat flow equations.

Unit I: Linear Differential Equations (**LDE**) and Applications (08 Hours)
LDE of n^{th} order with constant coefficients, Complementary Function, Particular Integral, Method of Variation of parameters, Cauchy's and Legendre's DE, Simultaneous and Symmetric simultaneous DE. Applications of LDE to engineering problems and Mass spring system.

Unit II: Laplace Transform **(LT)** and Applications (08 Hours)
Definition of LT, Inverse LT, Properties & theorems, LT of standard functions, LT of some special functions viz. Periodic, Unit Step, Unit Impulse, Error, Si(t) and Ei(t), first order Bessel's.
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).

Unit III: Fourier Transform (**FT**) (07 Hours)
Fourier integral theorem. Fourier 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 IV: Statistics and Probability (07 Hours)
Measures of central tendency, Measures of dispersion, Coefficient of variation, Moments, Skewness and Kurtosis, Correlation and Regression, Reliability of Regression estimates.
Probability, Probability density function, Probability distributions: Binomial, Poisson, Normal, Test of hypothesis: Chi-square test.

Unit V: Vector Calculus (08 Hours)
Vector differentiation, Gradient, Divergence and Curl, Directional derivative, Solenoidal and Irrotational fields, Vector identities. Line, Surface and Volume integrals, Green's Lemma, Gauss's Divergence theorem and Stoke's theorem.

Unit VI: Applications of Partial Differential Equations (PDE) (08 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. Higher Engineering Mathematics by B.V. Ramana (Tata McGraw-Hill).
2. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).

Reference Books:
1. Advanced Engineering Mathematics, 10e, by Erwin Kreyszig (Wiley India).
2. Advanced Engineering Mathematics, 2e, by M. D. Greenberg (Pearson Education).
3. Advanced Engineering Mathematics, 7e, by Peter V. O'Neil (Cengage Learning).
4. Differential Equations, 3e by S. L. Ross (Wiley India).
5. Introduction to Probability and Statistics for Engineers and Scientists, 5e, by Sheldon M. Ross (Elsevier Academic Press)
6. Partial Differential Equations for Scientists and Engineers by S. J. Farlow (Dover Publications, 1993)

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

Savitribai Phule Pune University
SE (Chemical Engineering) 2020 Course
209341: Industrial Chemistry-I
Credits: 3+2

Teaching Scheme	**Examination Scheme**
Theory: 3 hrs. /Week	Insem : 30 marks
Practical:4Hrs./Week	End Semester: 70 marks
	Practical : 50 marks

Prerequisites: Knowledge of fundamental Chemistry up to XII standard and first year Engineering Chemistry.

Course Objectives

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

Course Outcomes

On completion of the course, the students will be able to

- Analyze the type of forces and synthesize the materials based on their properties
- Estimate the kinetics of reaction and analyze the factors controlling the rate of reactions.
- Analyze the given chemical substance by different Instrumentation techniques
- Estimate the quantity of solute and synthesize the solution based on the properties.
- Evaluate the mechanism of reactions and apply proper factor for increasing the yield of the desired product.
- Apply the basic concepts of dyes and synthesize industrially important dyes.

Unit I: Bonding and Reactivity (L07)

Covalent Bonding- Introduction to VBT, 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 N2, O2 , 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.

Unit: II **Reaction Dynamics & Photochemistry** (L07)

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 using steady state approximation. Photochemistry: Introduction, Grotthus –Draper law, Stark-Einstein law, quantum yield, examples of photochemical reactions kinetics of i) H_2, Cl_2 reaction ii) dimerisation of anthracene.

Unit: III Instrumental methods of Analysis **(L07)**

Chromatography: Adsorption and partition principles, Study of TLC, column, HPLC, Gas Chromatography and their applications. b) Optical methods: UV, Lambert-Beer law, application of UV visible, IR spectroscopy-introduction, instrumentation, applications, identification of functional groups, cis and trans isomers, H-bonding (inter or intramolecular), strength of bond. Flame photometry- principle, instrumentation and applications.

Unit: IV Solution (L07)

Solution:-definition, 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. Numerical on all above.

Unit: V Reaction Mechanisms (L07)

Substitution at saturated carbon (SN1,SN2) - 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, 2Eliminations- E1 mechanism, E2, (Saytzeff, Hoffman products), factors favoring it. Rearrangements- Beckmann, Claisen, Favorskii.

Unit VI: Heterocyclic compounds and Dyes (L07)

Aromaticity, preparation, reactions of pyrrole, furan, pyridine, and quinoline. Dyes-Nomenclature, methods of application, color and chemical constitution (chromophoreauxochrome theory), classification of dyes on the basis of chemical structure, diazotization and coupling for azo dyes ,synthesis of crystal violet, alizarin, methyl orange, phenolphthalein.

Books:

1 Inorganic chemistry - J.D. Lee
2 Physical chemistry -P L Soni
3 Physical Chemistry- Atkins
4 Instrumental methods of chemical analysis ----Chatwal -Anand
5 Analytical chemistry- Skooge and West
6 Reaction mechanism - Jerry March
7 Instrumental Methods of Analysis, H.H.Willard, L.L. Merritt and J.A. Dean & F.A Settle, CBS Publishers, 7th Edition, 1988

Suggested List of Practical’s (Any 8)

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 CCl4 and hence to
8 determine the molecular condition of iodine
9 To estimate sodium ion concentration in solution by flame photometer 10 Colorimetric estimation of cobalt/ nickel ion in solution
11 Preparation of aspirin from salicylic acid.
12 Estimation of Cu++ ions by spectrophotometer (Any six experiments from the above)
13 Identification of given organic compound (with maximum one functional group)
14 Systematic analysis (Minimum 4 compounds)
15 Determination of percentage composition of binary mixture using Ostwald’s viscometer

Savitribai Phule Pune University
SE (Chemical Engineering)-2020 Course
209342: Fluid Mechanics
Credits: 3+1

Teaching Scheme	**Examination Scheme**
Theory: 3 hrs. /Week	In Sem : 30 marks
Practical: 2 Hrs. /Week	End Semester: 70 marks
	TW: 25 marks, Oral: 25

Prerequisites:
Courses in Engineering Mathematics, Engineering Mechanics, Physics

Course Objective
1 To introduce basic concepts of fluid mechanics and their applications in Chemical Engineering.
2 To study basic equations of fluid flow and applications to determine losses occurring through pipelines.
3 To develop relationships among process or system variables using dimensional analysis.

Course Outcomes: On completion of the course, learner will be able to–
1 Determine fluid properties and rheological behaviour of fluids
2 Apply the equation of fluid statics and select manometers for the pressure measurement
3 Analyze basic equations of fluid flow and their applications to determine fluid flow rate by different devices.
4 Formulate mathematical equations for flow of fluid through different systems and determine different losses occurring in pipelines.
5 Develop correlations amongst the system variables using dimensional analysis and to study concept of boundary layer theory.
6 Select valves and pumps for transportation of fluid through pipelines and concept of fluidization.

Unit I Introduction (L07)
Fluid, Properties of fluid, classification of fluids, Newton's law of viscosity and numerical, rheological classification of fluids, types of flow, lines to describe the flow, application of fluid flow in Chemical Engineering.
Unit II Fluid Pressure and Measurement (L07)
Pascal's law, Hydrostatic law, concept of atmospheric, gauge, vacuum and absolute pressure, manometers, and pressure measurement by simple and differential manometer~~.~~
Unit III Basic Equations of Fluid Flow and Flow Measuring Devices (L07)
Basic equations of fluid flow: continuity equation, equation of motion, flow measurement using venturimeter, orifice meter, rotameter, pitot tube~~.~~
Unit IV: Flow of Incompressible Fluids in Conduits (L07)
Laminar flow through circular pipe: Hagen Poiseuille equation, relation between average and maximum velocity, friction factor chart, Darcy Weisbach equation, major and minor losses~~.~~
Unit V: Dimensional Analysis and Boundary Layer Theory (L07)
Fundamental dimensions of quantities, dimensional homogeneity, types of similarities dimensional analysis by Rayleigh's method and Buckingham's method, dimensionless numbers; Concept of hydrodynamic boundary layer, growth over a flat plate, different thickness of

boundary layer, drag on a flat plate, drag coefficient.

Unit VI: Fluidization and Transportation of Fluids (L07)

Fluidization, types of Fluidization, minimum Fluidization velocity, entrainment in Fluidization, Operating characteristics of gas-solid, liquid –solid and liquid – gas, fluidized beds; different types of valves and pumps, blowers and compressors cavitations.

Text Books:

1. McCabe,W. L, J. Smith, and P. Harriot, Unit Operations of Chemical Engineering, McGraw-HillInternational Edition, Seventh edition,(2004).

2. Modi, L.P., Seth, S.M., "Hydraulics and Fluid Mechanics", Standard Book House,New Delhi, 2002 .

3. Noel de Nevers; Fluid Mechanics for Chemical Engineers, Third Edition; McGraw Hill, (2005).

4. M. Coulson, J.F. Richardson, with J.R. Backhurst and J.H. Harker, Coulson, Richardson Chemical Engineering, Volume-1", 6th ed., Butterworth-Heinemann,1999

Guidelines for Instructor's Manual

The Instructor's manual should include aim, theory, procedure, figures, observations, calculations and results for each experiment.

Guidelines for Student's Lab Journal

Laboratory journal should be completed by the students in his/her own hand writing.

Guidelines for Lab:

Assignment or practical work write-up should be submitted in the next laboratory session. Assessment should be carried out with grades.

List of Laboratory Assignments

1. Determination of viscosity.
2. Reynolds experiment to determine laminar and turbulent flow.
3. Bernoulli's theorem
4. Flow through venturimeter
5. Flow through orifice meter
6. Flow through rotameter
7. Major losses
8. Minor losses
9. Characteristics of centrifugal pump
10. Verification of stokes law
11. Flow through packed bed
12. Flow through Helical coil
13. Flow through Spiral coil

Note: Minimum any eight experiments to be performed from above list of experiments.

Savitribai Phule Pune University
SE (Chemical Engineering) 2020 Course

209343: Engineering Materials

Credits: 3+1

Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs /Week	In-Sem: 30 marks
Practical: 2Hrs/Week	End Semester: 70 marks
	Oral: 25marks

Prerequisites: First year courses in engineering.

- **Course 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

- **Course Outcomes:** On completion of the course, learners will be able to

1. Describe scope of Engineering materials, properties of materials and Selection of materials
2. Test different materials and describe organic materials.
3. Define corrosion, describe it's types, Control and prevent corrosion.
4. Describe polymers Compare types of polymerization and classify plastics, rubbers.
5. Describe Nanomaterials and its synthesis.
6. Test internal properties of engineering materials.

Unit I: Introduction: (L07)

Scope of engineering materials, Definition and explanation of- Melting point, Boiling point, Specific heat, Thermal, conductivity, Thermal expansion, Thermal insulation, Stresses, Strain, Yield stress, Fatigue, Creep.

Unit II: Testing of Engineering Materials: (L07)

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.

Unit III: Metals and Organic Materials: (L07)

Iron – Carbon diagram high and low temperature material, insulation, refractories.
Definition and importance of Polymer Addition and condensation Polymerization Plastics: definition, classification, general properties and uses Rubbers : definition, classification, general properties and uses Compare natural and synthetic rubber Vulcanizing of rubber

Unit IV: Corrosion and Its Prevention: (L07)

Definition of corrosion, Types of corrosion: Direct corrosion, Electro-chemical corrosion, Galvanic corrosion, High temperature corrosion , Factors affecting corrosion rate Methods for control and prevention of corrosion.

Unit V: Nanomaterials: **(L07)**

Classification, synthesis, characterization and application of Nanomaterials – Fullerenes, Bucky balls, carbon Nano tubes, fullerenes. Nano particles – silver Nano-particles. Applications of Nano materials in Chemical Industry

Unit VI: Experimental Techniques: **(L07)**

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.

Textbooks:

1. James F. Shacketford, introduction to material science, McMillan publishing company, New York 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. Introduction to Nano Technology, John Wiley & Sons by Charles P Poole, Frank J Owens.
6. Nano materials, synthesis, properties and applications, Institute of physics publishing, Bristol and Philadelphia, by A.S. Edelstein and R.C. Kamarhati
7. R. A. L Jones, Soft Condensed Matter, Oxford University Press, 2002.
8. William D. Callister, David G. Rethwisch Materials Science and Engineering: An Introduction, Wiley Publisher.
9. B. S. Mitchell An Introduction to Materials Engineering and Science for Chemical and Materials Engineers, John Wiley & Sons, 2004.

Guidelines for Student's Lab Journal:

Laboratory journal should be completed by the students in his/her own hand writing.

Guidelines for Lab /TW Assessment

Assignment or practical work write-up should be submitted in the next laboratory session. Assessment should be carried out with grades.

Guidelines for Conduct of Laboratory Course

- Arrangements for the practical should be done prior General laboratory safety instructions should be told to the students.
- Specific chemicals, machinery, hardware handling instructions should be given in the instructions
- Aim and objectives of the practical should be explained.
- After completion of experiment, review the attainment of aim and objectives of the experiment.

Suggested List of Laboratory Assignments:

1. Study of properties of polymeric materials; impact test and polymeric Tests. Synthesis of Polymers like nylon, PVC, PTFE etc
2. Different types of hardness test on metals. i.e. Rockwell hardness test, Brinell hardness test, Shore Scleroscope tests.
3. Izod and Charpy impact test on mild steel, copper, brass and aluminum.
4. 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.
5. Study experiments based in, i) Dye penetration ii) Rubber lining, iii) Ultrasonic test, iv) Heat treatments.
6. Study of Nanomaterials, Synthesis of Nanomaterials.
7. Study of Moisture Adsorption by Nanomaterials.
8. Study of Temperature V/S Relative Humidity for Nanomaterials.
9. To synthesize gold/silver (Au/Ag) Nanoparticles and record the optical absorption spectra using simple absorption spectrometer.
10. To synthesize zinc oxide (ZnO) Nanoparticles using a chemical route and calculate the size using UV-Vis absorption spectrum.
11. To synthesize titanium Nanoparticles (TiO2) using a chemical route and determine the phase and size using X-ray diffraction. (Using Scherrer formula).
12. To synthesize the Fe2O3 Nanoparticles of different shapes and calculate the average
13. size using scanning electron microscope (SEM) or transmission emission microscope (TEM).

Note: Minimum 8 experiments to be performed from the above suggested experiments.

Savitribai Phule Pune University
SE (Chemical Engineering)-2020 Course
209344: Process Calculations

Credits: 3+1

Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs. /Week	In sem : 30 marks
Tutorial:1 Hr/Week	End Semester: 70 marks
	TW; 25 Marks

Prerequisites

Basics Mathematics, Applied Sciences, Momentum Transfer

Course Objective

1 Develop ideas in dimensional analysis and to be familiar with different unit systems and conversion from one set of system to another.
2 Understand the various unit operations and unit processes performed in a chemical industry.
3 Learn fundamentals of stoichiometry and apply the material balance concept and precisely calculate the amount of materials required to carry out the suitable unit operation or process.
4 Learn the application of the general energy balance equation and precisely calculate the energy requirements of the unit operation or process involved.

Course Outcomes

On completion of the course, learner will be able to
1. Calculate the composition of materials.
2. Apply the various laws governing solid, liquid and gas phases.
3. Perform material balance with and without chemical reaction.
4. Perform material balance for various unit operations or processes in Chemical Engineering.
5. Calculate the energy requirement for various unit operations or processes in Chemical Engineering.

Unit I: Mathematical Principles (L07)

Introduction to unit processes and operations and their symbols, process flow sheet, Concept of steady and unsteady state operations, Units and dimensions: basic and derived units, different ways of expressing units and quantities, conversion of units, properties of pure substances, PVT behavior, ideal and real gas laws. Mole fractions and partial pressures, application of Dalton's, Amagat's, Henry's laws, concept of vapor pressure, Raoult's law and its applications, vapor pressure plots and effect of temperature on vapor pressure.

II: Material Balance for Physical Systems (L07)

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 Balance for Reacting Systems (L07)

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

Unit IV: Energy Balance **(L07)**

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 **(L07)**

Distillation, humidification, absorption and stripping, extraction and leaching, crystallization, Psychrometry, drying, evaporation, introduction to stoichiometry and industrial problems

Unit VI: Fuels and Combustion **(L07)**

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

Textbooks:

1. Bhatt B.I. and Vora S.M., "Stoichiometry", 2nd Edition, Tata McGraw Hill, New Delhi, 2004.
2. Hougen O.A., Watson R.M. and Ragatz R.A., "Chemical Process Principles Part I", 2nd Edition, CBS Publications, 1976. (ISBN : 9798123909539)
3. David M. Himmelblau, "Basic Principles and Calculations in Chemical Engineering", 8th Edition, Prentice Hall of India, New Delhi, 2012. (ISBN : 0132346605)
4. Narayanan. K.V. and Lakshmikutty.B, "Stoichiometry and Process Calculations", 2nd a. Edition, Prentice Hall of India, New Delhi, 2009. (ISBN : 8120329929)
5. Venkatramani V, Ananatharaman N, Sheriffa Begum, "Process Calculations", 2nd Edition,Prentice Hall of India, 2011.
6. Richard M. Felder, Ronald W. Rousseau, "Elementary Principles of Chemical Processes", 3rd Edition, John Wiley and Sons, 2005.

Tutorial

To apply the knowledge of the software like ChemCad/ASPEN/DWSIM to solve at least five industry problems of chemical engineering unit operations or processes based on material balance with and without chemical reactions and energy balance.

Savitribai Phule Pune University
SE Chemical Engineering - 2020 Course
209345: Soft Skills
Credits: 1

Teaching Scheme	**Examination Scheme:**
Practical: 02 Hrs/Week	TW: 25 marks

With a view to meet the trained human resource requirements of the Chemical Process and allied industries, students of Chemical Engineering will go through soft skills. The training of students will be conducted in order to improve their personality. This course has an objective of helping them to find suitable jobs by inculcating soft skills components through appropriate training.

- Art of Communication, Importance of internal and external communication. General Communication process, verbal & Non-verbal Communication. Effective Listening skis.
- Interpersonal Skills, Effective presentation skills, Self-awareness. Dealing with emotions. Team work. Leadership qualities.
- Professional etiquettes, Importance of per-placement talks. How to prepare for a Campus interview. Asking right questions during and after pre-placement talks. Collecting relevant information about the visiting company.
- Preparation of resume Effective Interview and group discussion techniques. Effective body language. Undestanding psychology of interviewers. NLP (Neuro-linguistic programming) & NAC (NeuroAssociative conditioning) techniques. Mock interviews and Group Discussion.
- Effective goal setting. Developing a vision mission and purpose for successful professional life (Designing your career). Creative visualization. Power of positive thinking. Art of Living and leaving for professional success. Eustress & distress. Management of stress and strain through meditation & yoga.

Books Recommended:

1. Stephen R. Covey, The 7 habits of highly effective people, Free Press 1989.
2. Stephen R. Covey, The 8th habit, Free Press 1989.
3. Napoleon Hill, Think and grow rich, The Napoleon Hill Foundation, 2012.
4. Anthony Robins, Awaken the giant within, Free Press; New edition, 1992.
5. Nasha Fitter, You’re hired, Penguin India, 2009.

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 8, generally covering the topics mentioned above. For the purpose of assignments, extensive use of research papers published in technical journals and articles published in magazines and newspapers may be made available 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.**

Savitribai Phule Pune University
SE (Chemical Engineering) 2020 Course

209347 : Industrial Chemistry-II
Credits: 3+2

Teaching Scheme	Examination Scheme
Theory: 3 hrs. /Week	Insem: 30 marks
Practical: 4Hrs./Week	End Semester: 70 marks
	Practical : 50 marks

Prerequisites: Knowledge of fundamental Chemistry up to XII standard and first year Engineering Chemistry.

Course Objectives

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

Course Outcomes

On completion of the course, the students will be able to

- Apply the concept of naturally occurring polymer and synthesize the new polymers.
- Apply the theory of synthesis of complex and evaluate their properties
- Analyze the given chemical substance by different Instrumentation techniques.
- Understand catalyst and its mechanism and apply it in the synthesis of compounds
- Understand concept of isomerism and analyze different isomers and their properties
- Understand concept of thermodynamics and apply in chemical industries.

Unit I: Green Chemistry (L07)

Carbohydrate: Cyclic structure of glucose, cellulose, starches. Starch based products, Cellulose acetate, nitrate, ether. catalytic site of enzyme, factors affecting enzyme activity, definition, goals of green chemistry, efficiency parameters, need of green chemistry, Major applications, traditional and green path way of adipic acid, polycarbonate, indigo dye, ibuprofen, carbaryl

Unit II: Transition metals and Co-ordination chemistry (L07)

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 (L07)

Standard solutions and their preparations, Concentration terms, small scale units of concentration, 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: Surface Chemistry (L07)

(a) Adsorption: Introduction to Freundlich and Langmuir theories of adsorption, adsorption from

solution, B.E.T. Theory of adsorption of gases, Application of adsorption, numerical on above.
(b) Applications characteristics, types, adsorption theory of catalysis, promoters, poisons, industrial applications of catalysts; Zeolites- structure, properties , applications as catalyst for reactions (amination of alcohol. NOX pollution control, alkylation, cracking conversion of methanol), Hydroformylation using catalyst, coordination catalysts in Wackers process, carbonylation, photolysis of water.

Unit V: Stereochemistry (L07)

Introduction, classification interconversion of wedge formula, Fischer formula, Newman formula, conformation isomerism of ethane, propane, butane, cyclohexane, optical isomerism with 1 and 2 chiral centres, enantiomers, diastereomers and meso compounds, geometrical isomerism and E – Z nomenclature (compounds with one double bond)

Unit VI: Thermodynamics (L07)

Thermodynamics tems, First law of thermodynamics and its equation in adiabatic, isothermal, isochoric, isobaric process, Enthalpy and Enthalpy change in reaction, Hess's law, Cp, Cv Relation between them, Kirchhoff's law, its equation and application, Bond energies, Statement of second law of thermodynamic, concept of entropy and entropy change, free energy, Gibbs- **Helmholtz equation, criteria of spontaneity.**

Books:

1 Inorganic chemistry - J.D. Lee
2 Physical chemistry -P L Soni
3 Physical Chemistry- Atkins
4 Instrumental methods of chemical analysis ----Chatwal -Anand
5 Analytical chemistry- Skooge and West
6 Stereochemistry By - Ernest Eliel
7. Unit Process in organic synthesis By P. H. Groggins
8 Instrumental Methods of Analysis, H.H.Willard, L.L. Merritt and J.A. Dean & F.A Settle, CBS Publishers, 7th Edition, 1988

Suggested List of Practicals : (Any 8)

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 crystallization
9. Purification of organic compounds by crystalisation and sublimation (one each)
10. Determination of chloride content by Mohrs method
11. Preparation of nitrobenzene Sulphonation of benzene/toluene
12. To determine heat of crystallization of $CuSO_4.5H_2O$
13. To determine integral and differential heat of solution of a salt
14. To determine thermometric titration curve in the neutralization of strong acid and weak acids against strong base.

Savitribai Phule Pune University
SE Chemical Engineering - 2020 Course
209348: Heat Transfer
Credits: 3 +1

Teaching Scheme Online	**Examination Scheme:**
Theory: 03 Hrs / Week	In-Semester Exam: 30 Marks
Practical: 02 Hrs/Week	End Semester Exam: 70 marks
	Oral Exam: 25 marks

Prerequisites: Fluid Mechanics and Engineering Mathematics-I and II
Course Objectives:

1. To use heat transfer principles to understand the heat transport by conduction, convection and radiation.
2. To design variety of heat exchange equipment and evaporators.
3. To provide the basic tools to expose students to heat transfer applications in industrial processes.

Unit I: Conduction **(L07)**

Introduction, Heat Transfer and Thermodynamics, Modes of heat transfer, Heat transfer fluxes and resistances, Thermal conductivity, Fourier's law of conduction; General equation for conduction. Conduction through plane, cylindrical and spherical and composite walls, Heat losses and insulation, Critical insulation thickness, introduction to heat transfer with heat sources.

Unit II: Convection **(L07)**

Introduction, thermal boundary layer, Natural and forced convections, film thickness, heat transfer coefficient, various resistances, Empirical equations for convection heat transfer in laminar and turbulent flow through tubes, through annulus and over a flat plate. Reynolds analogy, Chilton-Colburn analogy, Dimensional analysis, dimensional groups used in heat transfer.

Unit III: Radiation **(L07)**

Radiant energy-distribution, various laws of radiation and their derivations, Planck’s law, Wien’s law, The Stefan-Boltzmann law for blackbody, Kirchhoff’s law, black body, gray body, emissive power; Exchange of energy between two surfaces; View factors, combined heat transfer by conduction, convection and radiation, Furnace calculations.

Unit IV: Boiling and Condensation **(L07)**

Introduction, importance of latent heat, Pool boiling and film boiling, concept of critical heat flux. Condensation: Modes and features, derivation of Nusselt equation on condensate film, condensation on vertical and horizontal plates, condensation on inside and outside pipes for horizontal and vertical flows.

Unit V: Heat Exchange Equipment **(L07)**

Types of heat exchangers; Co-current and counter-current flows, Fouling factors, choice of thermic fluids, Equivalent diameter; LMTD, correction factors, Temperature profiles in heat exchangers, pressure drop, Process design of heat exchangers including double pipe heat exchanger, Why multi-pass exchangers, shell and tube heat exchanger, effectiveness of co-current and counter-current heat exchangers, cross flow heat exchangers, Heat transfer equipment auxiliaries: Steam trap.

Unit VI: Evaporation **(L07)**

Introduction, solution properties, foaming, degradation due to high temperature, scaling, equipment material, types of evaporators, material and energy balance for single effect systems, boiling point elevation, capacity and economy, multiple effect evaporators. design of evaporators.

Books:

1. Holman J. P., "Heat Transfer", McGraw-Hill, Inc.
2. Kern D. Q., "Process Heat Transfer", McGraw-Hill, Inc.
3. Coulson, J. M., Richardson, J. E., "Chemical Engineering", Vol.- I, Pergamon Press.
4. Sinnott R. K., "Chemical Engineering", Vol.- VI, 4^{th} Edition, Chemical Engineering Design, Elsvier.
5. Cengel Y. A., "Heat and Mass Transfer" 3rd ed., Tata McGraw Hill Publications, New Delhi (2007)

Guidelines for Student's Lab Journal

Laboratory journal should be completed by the students in his/her own hand writing.

Guidelines for Conduct of Laboratory Course

- General laboratory safety instructions should be told to the students before performance of the practicals.
- Specific chemicals, machinery, hardware handling instructions should be given in the SOPs and displayed in the laboratory.
- Aim and objectives of the laboratory experiment/assignment should be explained.
- Review the attainment of aim and objectives of the experiment after completion of experiment.

List of Practical (Minimum 8 practical to be performed)

1. Heat conduction – Determination of thermal conductivity
2. Convection (Natural/Forced)-Calculation of heat transfer coefficient
3. Thermal radiation-determination of emissivity
4. Construction of pool boiling curve
5. Determination of heat transfer coefficient of Double pipe heat exchanger
6. Determination of heat transfer coefficient of Shell and tube heat exchanger
7. Material balance and energy balance of Single effect evaporator
8. Design of shell and tube heat exchanger/ Calculations using HTRI software
9. Design of multiple effect evaporators using software (Excel, Chemcad, Python, UNISIM, ASPEN Etc.)
10. Study of Finned tube heat transport
11. Heat transfer analysis of Plate Heat exchanger
12. Heat transfer in agitated vessels

Students will perform eight experiments and submit the journal however Practical No. 8 & 9 is compulsory

Savitribai Phule Pune University
SE (Chemical Engineering) 2019 Course
209349 Principles of Design
Credits: 3+1

Teaching scheme:	**Examination scheme**
Lecture: 3 hr/week	In Semester: 30 Marks
Practical: 2 hr/week	End Semester: 70 Marks
	Term-work: 25 marks

Course Prerequisites: Basic knowledge about materials and properties, Knowledge about stress, strain and loads, Knowledge about basics of mechanical engineering

Course Objectives:

1. Apply basic knowledge of strength of materials for designing machine components.
2. Analyze stresses and strains in machine elements and structures subjected to various loads.
3. To develop understanding about drawing of shafts, keys, couplings etc.
4. To impart the basic concepts of chemical engineering drawing, mechanical design and process design for different process equipments
5. Define the approach and solve process design problems by employing knowledge of mathematics.
6. Critically review design alternatives and select and size appropriate process equipment.

Course Outcomes:

Students completing this course should be able to:

1. Formulate and analyze stresses and strains in machine elements and structures subjected to various loads.
2. Apply multidimensional static failure criteria in the analysis and design of mechanical components.
3. Analyze and design power transmission shafts carrying various elements like keys and couplings with geometrical features.
4. Analyze and design structural joints like riveted and welded joints.
5. Select appropriate belt drive arrangement and bearings for required service.
6. Design pressure vessels for variety of unit operations (absorption/stripping, distillation, extraction, adsorption, crystallization, chemical conversions etc).

Unit 1. Basic considerations in design: (L07)

Concept of Stress, strain and modulus of elasticity, Factor of Safety, Stress Concentration, Lateral strain and Poisson's Ratio, Stresses due to static and dynamic loads. Thermal stresses, Impact stresses, Distinction between process design and process equipment design (mechanical design), Design Codes, Design working pressure and temperature, Design Loads, corrosion allowance, weld joint efficiency factor, proportioning of pressure vessels, selection of L/D ratio, optimum proportions

Unit 2: Design Preliminaries: (L07)

Shear force and bending moment, SFD and BMD for point load and uniformly distributed load, deflection in beams, bending stress, torsional shear stress, Principal stresses and principal planes, application of principal stresses in designing machine members, theories of failure.

Unit 3: Design of shafts, keys, and couplings: (L07)

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 rigid flange coupling

Unit 4: **Design of joints and drives: (L07)**

Joints: Design of riveted joints, strength and efficiency of a riveted joint, Types of welded joints, Design of welded joints, strength of transverse fillet welded joints, strength of parallel fillet welded joints, strength of butt joints

Drives: Types of belts and belt drives, Velocity ratio, slip and creep of the belt, length of belt, ratio of driving tension, condition for transmission of maximum power

Unit 5: Design of thin-walled pressure vessels: (L07)

Introduction to pressure vessels, types of pressure vessels, 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

Unit 6: Design of thick-walled pressure vessels (High pressure (L07)

Materials of construction, stresses in thick cylinder, prestressing 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

Reference Books:

1. R. S. Khurmi, J. K. Gupta, 2005, A Textbook of Machine Design, Eurasia Publishing House.
2. V. V. Mahajani, S. B. Umarji, 2014, Joshi's Process Equipment Design, Trinity Press.
3. L. E. Brownell, E. Young, 1963, Process equipment design, John Wiley, New York.
4. B. C. Bhattacharya, 2015, Introduction to Chemical Equipment Design, C.B.S. Publishers.
5. J. M. Coulson, J. F. Richardson, R. K. Sinott, 2005, Chemical Engineering Design Vol. 6, Pergamon Press.

Guidelines for Student's Lab Journal

Laboratory journal should be completed on regular basis. Index, illustrations should be properly written. Assignments given over and above the practical topics should also be attached in the journal.

Presentation in the journal should be neat.

Guidelines for Lab /TW Assessment

Assignment or practical work write-up should be submitted in the next laboratory session. Assessment should be carried out with grades.

Suggested List of Laboratory Assignments

Term-work shall consist of drawing of minimum 07 Sheets based on the above syllabus out of which **03 Sheets/practical should be performed (drawn) using PV-LITE design software compulsorily**. Every student should submit the sheets and journal which will form the term work.

SavitribaiPhule Pune University
SE Chemical Engineering - 2020 Course
209350: Chemical Technology I
Credits: 3

Teaching Scheme Online	**Examination Scheme:**
Theory: 03 Hrs / Week	In-Semester Exam: 30 Marks
	End Semester Exam: 70 marks

Course Outcomes: On completion of the course, learner will beable to

1. State basic principles of chemical process industry.
2. Describe various manufacturing processes used in chemical process industries.
3. Understand major engineering problems encountered in chemical process industries.
4. Determine process aspects like yield, byproducts formed,generation of waste.
5. Draw and explain process flow diagrams for a given process.
6. Understand use of various equipment/instruments used in process industry.

Unit I: Introduction: Chemical industries-facts and figures, Unit operation and unit process concepts, Chemical processing and role of chemical engineers. Chloro-Alkali Industries: Soda ash, Solvay process, dual process, Natural soda ash from deposits, Electrolytic process, Caustic soda.

Unit II: Phosphorus Industries: Phosphoric acid, Wet process, Electric furnace process, Calcium phosphate, Ammonium phosphates, Nitrophosphates, Sodium phosphate. Potassium Industries: Potassium recovery from sea water.

Unit III: Nitrogen Industries: Ammonia, Nitric acid, Urea from ammonium carbonate, Ammonium nitrate.

Unit IV: Soap and Detergents: Batch saponification production, Continuous hydrolysis and saponification process, Sulfated fatty alcohols, Alkyl-aryl sulfonates.

Unit V:Plastic Industries: Polymerization fundamentals, Polymer manufacturing processes, Ethenic polymer processes, Polycondensation processes, Polyurethanes.

Unit VI: Petroleum Processing: Production of crude petroleum, Petroleum refinery products, Types of refineries, Design of refinery, Choice of crude petroleum, Refinery processes, Pyrolysis and cracking, Reforming, Polymerization, Isomerization, Alkylation. Rubber: Elastomer polymerization processes, Rubber polymers, Butadiene-Styrene copolymer, Polymer oils and rubbers based on silicon.

Text / Reference:

1. Austin G.T., Shreve's Chemical Process Industries - International Student Edition, 5th Edition, McGraw Hill Inc., 1998.
2. Sittig M. and GopalaRao M., Dryden's Outlines of Chemical Technology for the 21st Century, 3rd Edition, WEP East West Press, 2010
3.Chemical Technology Vol. I, II, III, IV Chemical Engg. IIT Madras

Note: **Students should be sent to industrial visits for exposure to Chemical Industry.**

Savitribai Phule Pune University
SE (Chemical Engineering) 2020 Course
209351 : Mechanical Operations
Credits: 3+1

Teaching Scheme	**Examination Scheme**
Theory: 3 Hrs /Week	In-Sem: 30 marks
Practical: 2 Hrs./Week	End Semester: 70 marks
	TW: 25 marks, Oral: 25 marks

Prerequisites: First year courses in engineering.

Course Objectives:

1. To study properties of solids, separation and size reduction of solids.
2. To understand fluid solid separation using sedimentation, fluidization and beneficiation methods.
3. To study mixing and agitation, filtration, handling and conveying of solids.

Course Outcomes:

On completion of the course, learner will be able to

7. To select suitable type of screening and size reduction equipment for different particle sizes.
8. To select suitable type of thickeners and clarifiers for separation of suspended solid particles from liquid for example applications in Wastewater treatment plants.
9. To apply fluidization and beneficiation techniques in Chemical Industries.
10. To select a suitable type of agitator for mixing and agitation and to estimate power consumption in mixing and agitation.
11. To select a suitable type of filter for filtration of a slurry or a suspension.
12. To select a suitable type of conveyor for transportation of different types of solids.

Unit I : Screening and Size Reduction of Solids (L07)

Properties of solids, Performance of screening equipment / testing sieves, U.S.sieve series, Tyler standard sieve series, sieve shaker, types of screen analysis.Necessity of size reduction, Crushing efficiency, energy requirement calculations by using crushing laws. Classification of size reduction equipment: Crushers, Grinders, Ultrafine grinders, Cutters. Dry versus wet grinding. Open and closed circuit grinding

Unit II: Settling and Sedimentation (L07)

Motion of particle in fluid, drag force, drag coefficient. Gravity settling methods, Terminal falling velocity, Stoke’s law and Newton’s law of settling.Gravity sedimentation operations, Sedimentation test, Kynch theory, Determination of thickener area and depth of thickener. Thickeners, Clarifiers, Sedimentation centrifuges.

Unit III: Fluidization and Beneficiation Equipment (L07)

Types of fluidization, fluidized bed systems, determination of minimum fluidization velocity, flow through packed bed, applications of fluidized bed. Ergun equation and its derivation, Kozeny Carman equation, Darcy's law. Flotation cell, magnetic separator, cyclone separator, liquid cyclone, electrostatic separator, precipitator, scrubbers, fabric filter, mineral jig.

Unit IV: Mixing and Agitation (L07)

Types of Impellers, flow patterns in un-baffled and baffled tanks, Draft tube, mechanically agitated vessel, power requirement in mixing, performance of mixers, Paste and viscous material mixing, solid-solid mixing, Batch and continuous mixers.

Unit V: Filtration (L07)

Classification of filtration and filters. Theory of filtration-equations. Filter media and filter aids. Batch and continuous filters. Plate and frame filter press, filling and washing in a filter press, horizontal pressure leaf filters. Rotary drum vacuum filters. Centrifugal filters-basket type.

Unit VI: Handling and Conveying of Solids (L07)

Storage of solids, characteristics of bulk solids, Conveyors: Principle, Construction and Working. Advantages, Disadvantages and design calculations of Belt Conveyors, Screw conveyors, Chain & Flight conveyors, Bucket elevators and Pneumatic conveyors.

Textbooks:

1. McCabe W. L. &Smith J.C. "Unit Operations in Chemical Engineering". McGraw Hill Publications.
2. Coulson J. M. and Richardson J.F. "Chemical Engineering Vol. 2", Pergamon Press.
3. Badger W. L and 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.

Guidelines for Student's Lab Journal

Laboratory journal should be completed by the students in his/her own hand writing.

Guidelines for Lab /TW Assessment

Assignment or practical work write-up should be submitted in the next laboratory session. Assessment should be carried out with grades.

Guidelines for Conduct of Laboratory Course

- Arrangements for the practical should be done prior General laboratory safety instructions should be told to the students.
- Specific chemicals, machinery, hardware handling instructions should be given in the instructions
- Aim and objectives of the practical should be explained.
- After completion of experiment, review the attainment of aim and objectives of the experiment.

List of Laboratory Experiments (Minimum 8 Experiments to be performed)

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 Buhrstone mill.

4. To determine mixing Index of a mixture in Ribbon Blender. OR To determine mixing Index of mix in Sigma Mixer.
5. To determine filter medium resistance and specific cake resistance by using Rotary Drum.
6. To determine filter medium resistance and specific cake resistance by using Plate & frame filter Press OR by using centrifugal filter.
7. To determine area of batch thickener by conducting batch sedimentation test.
8. To determine separation efficiency by using magnetic separator.
9. To determine separation efficiency by using froth flotation cell.
10. To determine minimum fluidization Velocity & to verify Ergun's Equation.
11. To study Vacuum filter.
12. To determine collection efficiency of Cyclone separator for various particle sizes and pressure drops.
13. To study conveying of solids by using working models of Belt conveyor, Chain conveyor, Screw conveyor, Bucket conveyor or elevator and pneumatic conveyor.

Savitribai Phule Pune University
SE (Chemical Engineering) 2019 Course
209352 Project-Based Learning
Credits: 02

Teaching Scheme:	**Examination Scheme:**
PR: 04 Hrs/Week	**TW: 50 Marks**

Course Objectives:

1. To improve the exposure, understanding and learning of the students.
2. To integrate knowledge and skills from various domains.
3. To help students gain confidence for meeting new challenges through lifelong learning.

Course Outcomes:

CO1: Student will be able to identify the problem and approach the solution comprehensively.
CO2: Students will comprehend the impact of engineering in a universal, economic, environmental, and societal context.
CO3: Students will be able to appreciate the need for, and develop a capability to employ life-long learning.

Group Structure:
Students can work individually or in a team of maximum 4.A faculty as a supervisor/mentor will be assigned to individual/groups.

Selection of Project/Problem:
The project will start by identifying latest problems related to various Chemical Engineering processes and will involve designing relevant solutions. The problems may be from environment or process industries or any other domain which can be studied and solved. The problem will give a foundation for the learning as it will be having a particular practical, scientific, social and/or technical sphere of influence. The problem should position as one precise case or demonstration of added general learning outcomes related to knowledge and/or modes of inquiry.
The learning from the problem will be based on the approach of solving the problem. Thus, the process of solving the problem will form the basis for Project-Based Learning (PBL). The solution of the problem can be elucidated from among three broad categories: Study-based, Laboratory-based and Computer-based. Under these broad categories, Project-Based Learning will lead to the learning of either or combination of understanding using literature survey, different computer programming tools, various lab opportunities for solving different problems, and understanding the preparation of report. This will lead to a well-rounded, lifelong learning for the students.
Assessment:
Progress of the PBL will be assessed on a weekly basis. The students and the mentor will be responsible for the weekly evaluation. The individual and the group performance must be monitored and will be continuously evaluated and be presented in the Continuous Assessment Sheet (CAS). An active participation from both the mentor and the students for the continuous assessment will enhance its efficiency and effectiveness.

The individuals or the groups should adhere to ethical standards, by maintaining a culture of authentic collaboration, self-motivation, peer-learning and personal responsibility. The mentors and the Department should support the students by providing proper guidance, explaining them the importance of the course and the various resources and services available for it.
The assessment will evaluate the various skills acquired during the learning through developing a model and/or report and/or presentation. The assessment will be considering:

- Individual assessment for each student (individual capacity, role and involvement in the project)
- Group assessment (defined roles, distribution of work, intra-team communication and teamwork)
- Documentation and presentation

Evaluation and Continuous Assessment:
It is recommended to have a continuous assessment of the course and therefore all the activities must be properly recorded on a regular basis. For the same, proper documentation in the form of Continuous Assessment Sheet (CAS), to be maintained by the mentor/Department and the students.

Recommended parameters for assessment, evaluation and weightage:

- Idea Inception **(5%)**
- Outcomes of PBL/ Problem Solving Skills/ Solution provided/ Final product **(50%)** (Individual assessment and team assessment)
- Documentation (Gathering requirements, design and modeling, implementation/execution, use of technology and final report, other documents) **(25%)**
- Demonstration (Presentation, User Interface, Usability etc) **(10%)**
- Contest Participation/publication **(5%)**
- Awareness/Consideration of Environment/Social ethics/Safety measures/Legal aspects **(5%)**

FACULTY OF SCIENCE AND TECHNOLOGY

Savitribai Phule Pune University

TE Chemical Engineering

2019 Course

Savitribai Phule Pune University Structure for TE Chemical Engineering- 2019 Course

Subject Code	Subject	L	P		Tut	ISE	ESE	TW	PR	OR	Total	Credits TH+PR
	SEMESTER-I											
309341	**Mass Transfer-I**	**3**	**4**		**-**	**30**	**70**		**50**	**-**	**150**	**3+2=5**
309342	**Chemical Technology -II**	**3**	**4**		**-**	**30**	**70**	**25**		**50**	**175**	**3+2=5**
309343	**Chemical Engineering Mathematics**	**3**	**-**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**3**
309344	**Chemical Engineering Thermodynamics**	**3**	**-**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**3**
309345	**Elective-I**	**3**	**-**		**-**	**30**	**70**	**-**	**-**	**-**	**100**	**3**
309346	**Computer Aided Chemical Engineering- I**	**-**	**2**	**-**	**-**	**-**	**-**	**25**	**-**	**-**	**25**	**1**
309347	**Seminar**	**-**	**-**	**-**	**1**	**-**	**-**	**50**	**-**	**-**	**50**	**1**
	Total	**15**	**10**		**1**	**150**	**350**	**100**	**50**	**50**	**700**	**21**
	SEMESTER-II											
Subject Code	**Subject**	**L**	**P**	**Tut**	**Interns hip**	**ISE**	**ESE**	**TW**	**PR**	**OR**	**Total**	**Credits TH+PR**
309348	**Chemical Reaction Engineering I**	**3**	**4**	**-**	**-**	**30**	**70**	**25**	**50**	**-**	**175**	**3+2=5**
309349	**Mass Transfer II**	**3**	**4**		**-**	**30**	**70**	**50**	**50**	**-**	**200**	**3+2=5**
309350	**Transport Phenomena**	**3**		**2***	**-**	**30**	**70**	**25**	**-**	**-**	**125**	**3+1=4**
309351	**Elective-II**	**3**	**-**	**-**	**-**	**30**	**70**	**-**	**-**	**-**	**100**	**3**
309352	**Internship**	**-**	**-**	**-**	**4**			**100**	**-**	**-**	**100**	**4**
	Total	**12**	**08**	**2**	**4**	**120**	**280**	**200**	**100**	**--**	**700**	**21**
	***Subject Teacher should conduct Tutorial of 2 Hrs per Batch per week. 8 Minimum Assignments including Numerical relevant to the subject to be submitted by each students as a part of Term Work.**											

Examination Duration: In semester: 60 min. End semester: 150 min. L: Lecture, P: Practical, T: Tutorial, TW: Term work, PR: Practical, OR: Oral.

ISE – In semester Examination, ESE - End semester Examination, Tut- Tutorial.

Elective-I
A. Chemical Industry Management
B. Food Technology
C. Polymer Engineering
D. Downstream Processing
Elective-II
A. Energy Conservation in Chemical Process Industries
B. Process Instrumentation and Control
C. Corrosion Engineering
D. Artificial intelligence and Data Science

309341: MASS TRANSFER –I

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
Practical : 4 Hours / Week	End Semester: 70
	Practical: 50
	Total: 150
	Credits:3+2=5

Unit 1: Introduction **7 Hrs**

General principles of Mass Transfer, classification of Mass Transfer Operations, choice of separation method, methods of conducting mass transfer operations, design principles. Diffusion Mass Transfer, Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, diffusion in solids, unsteady state mass transfer.

Unit 2: Inter-Phase Mass Transfer **7 Hrs**

Mass transfer coefficients in laminar flow and turbulent flow, theories of mass transfer, mass, heat and momentum transfer analogies. Inter-phase mass transfer, equilibrium in mass transfer, the two resistance theory, continuous co-current, countercurrent and crosscurrent processes, cascades.

Unit 3: Gas Absorption **7 Hrs**

Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculations of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction.

Unit 4: Humidification and Dehumidification- **7 Hrs**

Principles, vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.

Unit 5: Equipment for gas liquid operation **7 Hrs**

Types of columns, Types of trays, types of packing, Gas dispersal equipment – bubble columns, mechanically agitated vessels, tray towers. Liquid dispersal equipment – Venturi scrubbers, wetted wall columns, spray towers, packed columns

Unit 6: Drying **7 Hrs**

Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, design principles of tray dryer, rotary dryer, drum dryer, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

Practical:-

Minimum Ten practical to be performed out of the following:

1. Tray Dryer – To calculate rate of Drying
2. Rotary Dryer – To study the Characteristics of Rotary Dryer
3. Spray Dryer – To study the design and Operating Principles of Spray Dryer
4. Fluidized Bed Dryer – To study the characteristics of Fluidized bed Dryer
5. Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system
6. Winkelmann's method – To find the diffusion Coefficient of vapour in still air
7. To study Solid in air Diffusion
8. Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction
9. Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower
10. Cooling Tower– To study the characteristics of cooling tower
11. Humidifier and Dehumidifier – To study the Characteristics
12. Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient
13. Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column

References

1. Mass Transfer Operations – Treybal R.E., McGraw Hill

2. Chemical Engineering, Vol. I & II – Coulson J.M. and |Richardson J.F., McGraw Hill

3. Principles of Unit Operations in Chemical Engineering, Foust A.S.

4. Separation Techniques – King C.J. Design of Equilibrium Stage Processes - Smith B.D.

309342: CHEMICAL TECHNOLOGY –II

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
Practical : 4 Hours / Week	End Semester: 70
	Oral: 50
	TW:25
	Total: 150
	Credits:3+2=5

Unit I: Sulfur and Sulfuric Acid Industries: Elemental sulfur mining by Frasch process, Sulfur production by oxidation-reduction of H2S, Sulfur and sulfur dioxide from pyrites, Sulfuric acid. Contact process, Chamber process. Sea chemicals: Sodium-Magnesium compounds, different methods for different salt recovery. Electrolytic industry: Production of Aluminium, Magnesium. **7 Hrs**

Unit II: Sugar and Starch Industries: Sucrose, ,Extraction of sugar cane to produce crystalline white sugar, Extraction of sugar cane to produce sugar, Starch production from maize, Production of dextrin by starch hydrolysis in a fluidized bed. Pulp and Paper Industries: Sulfate pulp process, Chemical recovery from sulfate pulp digestionliquor, Types of paper products, Raw materials, Methods of production. **7 Hrs**

Unit III: Coal Chemicals: Destructive distillation of coal, Types of carbonization, Coke oven – construction, working and applications. Cements: Introduction, types of cements, properties and applications. Manufacture of Portland cement. Beneficiation & Production of Hydrated lime. Iron and Steel: Production of steel, blast furnace detail. **7 Hrs**

Unit IV: Surface coating industries: Types of surface coating; Paints, varnishes, distempers and enamels. Dyes and dye intermediates industry: Classification of dyes; Dye and dye intermediates; Production of some important dyes, lacquers and toners. Fuel and Industrial Gases: Technology options of producing producer gas, natural gas, water gas, nitrogen, oxygen and carbon dioxide. **7 Hrs**

Unit V: Pharmaceutical industries: Classification of drugs; Drug production based on some selected unit processes. Bio Pharmaceutical Industry: Production of penicillin, antibiotics. Agrochemical industries: Manufacturing process of some important pesticides, insecticides, fungicides, fumigants, plant growth regulators, yield stimulators and herbicides. **7 Hrs**

Unit VI: Petrochemical Industry: C1 Compounds: Production of Methanol, Formaldehyde, and Halogenated Hydrocarbons. C2 Compounds: Production of Ethylene and Acetylene- Steam Cracking of Hydrocarbons, Ethylene Dichloride, Vinyl Chloride. C3 Compounds: Production of Propylene by Indirect Hydration, Acetone, Cumene Aromatic Compounds: Production of Phenol, Phthalic Anhydride and Styrene. **7 Hrs**

Practical (Minimum Eight):

1. Production of Sulfur
2. Production of C1, C2 and C3 compounds
3. Production of single /Triple Super Phosphate/ Ammonium Phosphate.

4. Production of paper.
5. Production of ethyl alcohol
6. Production of soap
7. Production of Detergent
8. Production of Portland cement
9. Mass balance calculations of any two processes using process calculation approach.
10. Heat balance calculations of any two processes using process calculation approach.
11. Calculations based on recycle operations.
12. Process flow sheets drawing of any two processes using CAD.

References:

1. Chemical Technology- Venkateshwaralu, Vol. I, II, III, IV Chemical Engg. IIT Madras
2. Outlines of Chemical Technology, Dryden
3. Unit Processes in Organic Synthesis, Groggins P., McGraw Hill.
4. Chemical Process Industries, Shreeve R.N., McGraw Hill.
5. Industrial Chemicals, Feith – Keys and Clerk.

309343: CHEMICAL ENGINEERING MATHEMATICS

Teaching Scheme:	Examination Scheme:
Lectures : 3 Hours / Week	In Semester: 30
	End Semester: 70
	Total: 100
	Credits:3

Unit 1: Error and Roots of Equation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Error Definition, Round of Error, Error Propagation, Total Numerical Error. Bracketing method: Graphical, Bisection, False-Position. Open Method: Single variable Newton Raphson, Secant method, multiple roots. Roots of Polynomial: Mullers Method. Caley Hamilton method.

Unit 2: Linear Algebraic Equation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods :Gauss Elimination, Gauss-Jordon Elimination, LU Decomposition, Tridiagonal Systems (Thomas Algorithm), Gauss Seidel and Relaxation Method. Eigen values and Eigen Vectors of Matrices.

Unit 3: Regression Analysis and Interpolation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods. Statistical Data Analysis: Least square method, curve fitting and regression. Linear Regression, Polynomial Regression, Multiple Linear regression, Non-linear regression, Newton's Interpolation, Newton's Divided Difference Interpolation, Polynomial, Lagrangian Interpolation. Numerical Integration: Trapezoidal method, Simpson 1/3rd rule, Simpson 3/8th rule

Unit 4: Ordinary Differential Equation **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods. Euler's method, Modified Euler's method, 2nd order Runge-Kutta Method, 4th order Runge-Kutta method, Systems Equations. Picards method of successive approximations.

Ordinary Differential Equation: Boundary Value Problems, Taylor series method.

Unit 5: Finite Difference Methods **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods .Introduction to finite difference method. Boundry value problems of exact differential equations up to second order. Hyperbolic equations, Finite difference approximations to derivatives. Elliptical Equation, Control Volume Approach, Heat Conduction Equation.

Unit 6: Optimization **7 Hrs**

Problems based on Process Calculation, Fluid Flow operation and Heat Transfer to be solved using following methods: Basic concept of optimization and formulation, Nature of optimization. Linear programming by simplex method. Applications of optimization based on simplex method. Golden search method and its application.

References

1. Steven C Chapra, Raymond P Canale, ‘Numerical Methods for Engineers’, 5th Edition, Tata McGraw-Hill Publishing Company Limited, New Dehli, 2007
2. Santosh K Gupta, ‘Numerical Methods for Engineers’, New Age International Publishers Limited, 1995
3. Thomas F Edgar, David M Himmeblau, Leon S Lason, ‘Optimization of Chemical Processes’, 2nd Edition, Mc-Graw Hill Publication, 2002
4. S. Balgurusamy, ‘Numerical methods’, Tata McGraw Hill Publication, New Delhi, 2008
5. Curtise F Gerald, Patrick O Wheatley, ‘Applied Numerical Analysis’, 6th Edition, Pearson Education Asia, 2002.

309344: CHEMICAL ENGINEERING THERMODYNAMICS

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit 1: Solution Thermodynamics **7Hrs**

State and path functions, intensive and extensive properties, Fundamental property relations for closed systems, Maxwell relationships, residual properties, chemical potential, effect of T and P on chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, Pointing factor, for species in solution, generalized correlations, ideal solutions.

Unit 2: Solution Thermodynamic applications **7Hrs**

Excess properties, VLE data, fugacity, activity coefficients, excess Gibb's energy, Margules equation, van Laar equation, property changes of mixing.

Unit 3: Vapor-liquid equilibrium **7Hrs**

The nature of equilibrium, criteria of equilibrium, effect of T and P on VLE, azeotropes, the phase rule, Duhem's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, VLE from K-value correlations, Flash calculations, Henry's law.

Unit 4: Phase Equilibria **7Hrs**

Equilibrium and stability, liquid-liquid equilibrium, solid-liquid equilibrium, osmotic equilibrium and osmotic pressure, thermodynamic consistency.

Unit 5: Chemical Reaction Equilibria **7Hrs**

The reaction coordinates, Application of the criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant, effect of temperature on equilibrium constant, evaluation of the equilibrium constant.

Unit 6: Equilibrium constant **7Hrs**

Relation of equilibrium constant to composition, calculation of equilibrium conversion for single reactions, The phase rule and Duhem's theorem for reacting systems, multireaction equilibria, Introduction to fuel cells.

References:-

1. Introduction to Chemical Eng. Thermodynamics: J. M. Smith, H. C. Van Ness & M. M.Abbott.
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

309345: Elective-I

A. Chemical Industry Management

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit 1: Management Science **7 Hrs**

A. Management, its growth, concepts of administration and management of organization. Definition of management, functions, authority and responsibility, unity of command and direction decision making in management by objectives.

B. Personality: Physical appearance, body language, voice, communication style, content of communication, enriched communication through Sensory Specific Language. Business style and professional image: Dress codes, Guidelines for appropriate business attire.

C. Business organization: Different forms of organization, their formation and working, different organization structure- line organization, functional organization, line and staff organization.

Unit 2: Personnel Management **7 Hrs**

Manpower planning, sources of recruitment, selection and training of staff, job evaluation, merit rating, performance appraisal, wage administration and system of wage payment, incentive, motivations, industrial fatigue, trade unions – industrial relations. Introduction to personal selling & salesmanship: Defining personal selling and salesmanship, Selling as a profession, Objectives and importance of personal selling, Essentials of personal selling, traditional & modern selling approach, ethics in Selling, role of selling in marketing, types of selling, qualities of winning sales Professionals-physical, mental, social and character traits.

Unit 3: Purchase and stores management **7 Hrs**

Concepts of quotation, tenders and comparative statement, inspection and quality control, inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, stores management, functions of storekeeper, methods of inventory : LIFO, FIFO. Credit analysis and appraisal principles of credit management: Principles of lending –evaluation of borrower – sanction limit-principles of good lending.

Unit 4: Marketing management **7 Hrs**

Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion. Introduction to product management: Product management as a basis of marketing organization structure. Role of product manager, skills required for product management. Product management in consumer product industry vs industrial product industry. Overview of product level marketing plans.

Unit 5: Export and import management **7 Hrs**

Concepts of international trade, duties, antidumping duty, cost involved in exporting a product, pricing of export product. Government aids for export promotion, export houses, export promotion counsel, MODVAT, patent and patent rights. Quality Management: TQM, quality circles, ISO systems. Inflation: Meaning, types of inflation, causes, effects, control of inflation, value of money, index numbers, construction, utility, limitations, business cycles, phases of business cycles.

Unit 6: Management Laws **7 Hrs**

Concepts of contract act, offer, and acceptance, types of contracts, void contract, concept of guarantee and warranty. Introduction of MRTP and FERA. Work study: Work measurement, motion and time study flow process chart, flow diagram, silo chart, string chart, therbligs. Patent law: Patent cooperation treaty, patent act 1970, procedure for filing patent applications, patent granting procedures, revocation.

References:

1. Stonier, A. W. and Hague, D. C., “A Text Book of Economic Theory”, Longman.
2. Bach, George Leland, “Economics -Analysis, Decision Making and policy”, Prentice Hall Inc. Englewood Cliffs N. J.
3. Bonham F, “Economics”, Sir Isaac Pitman and Sons Ltd., London.
4. Seth, M. L., “Principles of Economics”, Lakshmi Narayan Agarwal, Agra.
5. Agarwal, A. N., “Indian Economy”, Vikas Publishing House Pvt. Ltd., New Delhi.
6. Datta R. and Sundharam, K. P. M., “Indian Economy” S. Chand & Co. Ltd., New Delhi
7. Peter F. Drucker, “The Practice of Management”, Allied publishers pvt. ltd., Bombay.
8. Barat, Nikhil, “Production management & Control”, Academic Publishers, Calcutta.
9. Garrett, Leonard J. & Silver, Milton, “Production Management Analysis”, Harcourt Brace Jovanovich, Inc. New York.
10. Kuchhal, S. C., “Financial Management: An- Analytical & Conceptual Approach”, Chaitanya Publishing House, Allahabad.
11. Pandey, L. M., “Financial Management”, Vikas Publishing House Pvt. Ltd., New Delhi.
12. Kotlel, Philip, “Marketing Management: Analysis, Planning & Control”, Prentice –Hall of India Pvt. Ltd: New Delhi
13. Sinha, J. C., “Marketing and Salesmanship”, S. Chand & Co., Delhi. 14. H.L. Ahuja, “Modern economics”, S. Chand and co. ltd., New Delhi.
15. Management for Business and Industry-C. S. George Jr.
16. Principles of management- Knoots and O. Donnell.

309345: Elective-I

B. Food Technology

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit I: Principles of Food Processing **7 Hrs**

Scope and importance of food processing. Principles and methods of food preservation freezing, heating, dehydration, canning, additives, fermentation, irradiation, extrusion cooking, hydrostatic pressure cooking, dielectric heating, microwave processing, storage of food, modified atmosphere packaging. Refrigeration, freezing and drying of food, minimal processing, radiation processing.

Unit II: Technology of Milk And Milk Products **7 Hrs**

Sources and composition of milk, processing of market milk, standardization, toning of milk, homogenization, pasteurization, sterilization, storage, transportation and distribution of milk. Milk product processing-cream, butter oil, cheese, cheese spread, condensed milk, evaporated Milk, whole and skimmed milk powder, ice cream, khoa, channa, paneer, fermented milk products, dahi shrikhand and similar products.

Unit III: Fruit and Vegetable Technology **7 Hrs**

Principles and methods of fruit and vegetable preservation. Composition and related quality factors for processing. Principles of storage of fruits and vegetables. Types of storage: natural, ventilated low temperature storage. preservation of fruits and vegetables by heat, chemicals, sugar, salt, fermentation, drying etc. canning of fruits and vegetables, tin cans, glass containers seaming technology, aseptic canning technology. Fruit and vegetable juices, preparation of syrups, cordials and nectars, juice concentrates pectin and related compounds, jams, jellies, marmalades, preserves.

Unit IV: Principles of Food Engineering **7 Hrs**

Unit operation in food engineering processing of food grains, theory of size reduction equipment's and effect of size reduction on foods, evaporation extrusion, hot air dehydration, baking, roasting and hot oil frying theory, equipment's, applications and effect on food materials for freezing / freeze drying and freeze concentration.

Unit V: Food Packaging **7 Hrs**

Introduction to packaging. Packaging operation, package-functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods for prevention, shelf life of packaged foodstuff, methods to extend shelf-life. Food containers-rigid containers, corrosion of containers (tin plate). Flexible packaging materials and their properties. food packaging materials and their properties. Food packages-bags, pouches, wrappers, carton and other traditional package, containers-wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks.

Unit VI: Food Quality Assurance **7 Hrs**

Objectives, importance and functions of quality control. Methods of quality, concepts of rheology, assessment of food materials-fruits, vegetables, cereals, dairy products, meat, poultry, egg and processed food products. Food regulations, grades and standards, concept of Codex Almentarious/HACCP/USFDA/ISO 9000 series etc. Food adulteration and food safety, basis, trends and composition of India's foreign trade.

Reference Books:

1) Lewis, M.J. 1990. Physical Properties of Food and Food Processing Systems. Wood head, UK.

2) Charm S. E. Fundamentals of food Engineering, AVI, 1963.

3) Hall, Farral, Rippen, Encyclopedia of food Engineering, AVI 1970.

4) Mirajkar M, Menon- Food Science and Processing Technology Vol I & II New Delhi, Kanishka Publishers.

5) Fellows P. , Ellis H., 1990 – Food Processing Technology Principles and Practice –New York

6) Held man, D.R. and Lund, D.B. Ed. 1992. Handbook of Food Engineering marcel Dekker, New York.

7) Rang Anna, S. 1986. Handbook of Analysis and Quality Control for Fruits and Vegetable Products. Tata McGraw Hill, New Delhi.

8) Painy, F.A. and Painy, H.Y. 1983. A Handbook of Food Packaging. Leonard Hill, Glasgow, UK.

9) Salunkhe, D.K. and Kadam, S.S. Ed. 1995. Handbook of Vegetable Science and Technology, Production, Composition, Storage and processing Marcel Dekker, New York.

309345: Elective-I

C. Polymer Engineering

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit – I: Introduction and Classification of Polymers. Thermosets, Thermoplastics, Linear Branch, Cross Linked Polymers. Factors influencing the polymer properties. **7 Hrs**

Unit – II : Addition & Condensation polymers, Polymerization Techniques, Bulk Solution Suspension, Emulsion, Interfacial Polymerization with their merits & Demerits. **7 Hrs**

Unit – III: Molecular Weights, Mn, Mw, Mv, Polydispersity Index. Different Methods of determination of Molecular weight. Effect of Molecular weight on Engg. Properties of Polymers, Numerical based on theory.

7 Hrs

Unit – IV: Kinetics of free radical polymerization (initiation propagation & termination.) Chain transfer agents. Kinetic of Step growth polymerization. Copolymers & its Kinetics Coordination Polymerization. **7 Hrs**

Unit – V: Polymer additives, compounding. Fillers plasticizers lubricants colourants UV stabilizers, fire retardants, antioxidants. Different moulding methods of polymers. **7 Hrs**

Unit – VI: Manufacturing of typical polymers with flow-sheet diagrams, their properties & applications: PE, PP, PS, PPO, Teflon Polyesters, Nylons, Kevlar, Nomex. Thermosets like Epoxies, unsaturated polyesters, phenolics, vinyl esters, cynate esters etc. Elastomers like natural rubber, butyl, neoprene, Bunas Silicons, Thiokol etc. Numerical/Problems based on Theory **7 Hrs**

References:

1. Principals of Polymerization, Odion G.G., MaGraw Hill.

2. Text Book of Polymer Science, Billmer F.W, John Wiley & Sons.

3. Polymer Science, Gowarikar et al.

4. Text Book of Polymer Science, F. Rodrigues.

5. Polymer Science & Technology, Fried J.R., PHI.

6. Rubber Technology & Manufacturing, Blow C.M., Hepbun C.

7. Synthetic Rubbers Chemistry & Technology, D.C. Blackly.

8. Plastics by Brydson.

309345: Elective-I

D. Downstream Processing

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30
	End Semester: 70
	Total: 100
	Credits: 3

Unit I: Introduction: **7 Hrs**

Introduction to Downstream processes, examples. Applications & Advantages.

Unit II: Centrifugal separation: **7 Hrs**

Theory, application, equipment's, power requirement, chemical separation for Gas-Liquid system, Gas-Solid system. Super critical fluids extraction in food, pharmaceutical, environmental and petroleum applications, water treatment, desalination, Bio separation, dialysis, industrial dialysis.

Unit III: Downstream Processes in Petrochemical Industry: **7 Hrs**

Cryogenic distillation for refinery, petrochemical off gases, natural gases, gas recovery-Olefin, Helium, Nitrogen, Desulfurization - coal, flue gases

Unit IV: Advanced Distillation Processes: **7 Hrs**

Azeotropic & extractive distillation - residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, Column sequences, and heterogeneous azeotropic distillation.

Unit V: Energy conservation in separation processes: **7 Hrs**

Energy balance, molecular sieves - zeolites, adsorption, catalytic properties, manufacturing processes, hydrogel process, application, New trends.

Unit VI: Non-Ideal Mixtures and Ion Exchange: **7 Hrs**

Separations process synthesis for nonazeotropic mixtures, non ideal liquid mixtures, separation synthesis algorithm, Ion exchange - manufacture of resins, physical & chemical properties, capacity, selectivity, application, regeneration, equipment, catalysis use.

References:

1. Perry's "Chemical Engg. Handbook": McGraw Hill Pub.

2. Douglas J.M., "Conceptual Design of Chemical Processes", McGraw Hill

3. Liu Y.A., "Recent Developments in Chemical Process & Plant Design", John Wiley & Sons Inc.

4. Timmerhaus K.D., "Cryogenic Process Engg.", Plenum Press

5. Othmer Kirk "Encyclopedia of Separation Technology, Vol I & II", Wiley Interscience

309346: COMPUTER AIDED CHEMICAL ENGINEERING – I

Teaching Scheme: Practical : 2 Hours / Week	**Examination Scheme:** Term Work: 25 **Total: 25** **Credits:1**

Minimum 10 practical and a compulsory home paper.

Applications of numerical Techniques in chemical engineering to be evaluated by following methods:
Topics may include but are not restricted to:

1. Eigen values and Eigen vector computations for Level Control Applications.
2. Applications of Vectors to problems in Fluid Mechanics, Continuity equations, Stream lines, Equations of motion, Bernoulli's equations.
3. Numerical interpolation
4. Numerical integration.
5. Integration of ODE – Equation for Batch Reactions.
6. Numerical differentiation.
7. Root-finding method – two nonlinear equations.
8. Linear programming for solving Liquid Level in Tank model.
9. Data fitting.
10. Process calculation using MS-EXCEL.
11. Application of neural networks.
12. Fuzzy logic applications.
13. Application of support vector machines.
14. Design Algorithms
15. Non-linear optimization methods-Interacting and non-interacting systems
16. Regression Analysis.

Home paper for each student or group of students is compulsory.
(A paper written by a student may be five to six pages in double spacing, a few figures may get added.)

309347: Seminar

Teaching Scheme: Tutorial : 1 Hours / Week	Examination Scheme: Term Work: 50 Credits:1

The seminar may be a review of literature of specific phenomena/new process. Working model to demonstrate the principle, alternatively a small experimentation to investigate chemical engineering. Data/unit process/ unit operation. Based on this study focused report should be submitted. It is expected that the student collect information from reference books, journals and Internet. The report submitted should reveal the student's internalization of the collected information. Mere compilation from the net and other resources is discouraged.

Format of the Seminar report and TW assessment:

1. The Seminar report should be based on a detailed study of any relevant topic to Chemical Engineering, be neatly written or typed on white paper. The typing shall be with normal spacing and on one side of the paper [A-4 size].
2. The report should be submitted with front and back cover of card paper neatly cut and bound or spirally together with the text.
3. Front cover: This shall have the following details.
   a. Title of the seminar report.
   b. The name of the candidate with roll number examination seat number at the middle.
   c. Name of the guide below the candidate's details.
   d. The name of the institute and year of submission on separate lines at the bottom.
4. Seminar approval sheet.
5. The format of the text of the seminar reports:

   The report shall be presented in the form of a technical paper. The introduction should be followed by literature survey. The report of analytical or experimental work done, if any, should then follow. The discussion and conclusions shall form the last part of the text. They should be followed by nomenclature and symbols used followed by acknowledgement. The bibliography should be at the end. References should be written in the standard format. The total number of typed pages, excluding cover shall be about 25 to 30 only. All the pages should be numbered. This includes figures and diagrams. Two copies of the seminar report shall be submitted to the college. The candidate shall present the Seminar before the examiners. The total duration of presentation and after-discussion should be about 30 minutes max. [25 min + 5 min]. Audience can ask questions only if the examiner permits. [Such questions will not have any bearing on marks].

The assessment for the subject shall be based on

1. Report submitted.
2. Presentation.
3. Discussion.

SEMESTER: II

309348: CHEMICAL REACTION ENGINEERING –I

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week Practical : 4 Hours / Week	In Semester: 30 End Semester: 70 Practical: 50 TW: 25 **Total: 175** **Credits:5**

Unit 1: Kinetics of Homogeneous Reactions **7 Hrs**

Defining a rate equation and its representation, single and multiple reactions, elementary and non elementary reactions, molecularity and order of reactions, kinetic models for non-elementary reactions, searching mechanism, rate controlling step.

Unit 2: Analysis and interpretation of Batch Reactor data **7 Hrs**

Constant volume batch reactor, integral and differential methods of analysis, variable volume batch

Unit 3: Reactor Design **7 Hrs**

Introduction, conversion of mass in reactors, performance equation for ideal stirred tank reactor, tubular flow reactor, batch reactor, space time and space velocity. Isothermal Reactors for single Reactions: Batch reactor, mixed versus plug flow reactors, second order reactions, graphical comparison, multiple reactor system, plug flow reactors in series and in parallel, equal size mixed reactors in series, reactors of different types in series, recycle reaction (flow, batch), auto-catalytic reactions, non- steady flow semi-batch reactors.

Unit 4: Multiple reactions **7 Hrs**

Parallel and series reactions, performance of various ideal reactors, qualitative and quantitative discussion for multiple reactions, instantaneous and overall fractional yield.

Unit 5: Temperature and pressure effects **7 Hrs**

Temperature dependency from Arrhenius law, thermodynamics, collision theory, transition state theory, comparison of theories, rate of reactions predicted by theories, single reactions: heat of reaction from thermodynamics, equilibrium constants from thermodynamics, graphical design procedure, heat effects, adiabatic operations, non adiabatic operations.

Unit 6: Deviations from Ideal Reactor **7 Hrs**

Self mixing of a single fluid & two miscible units, Residence time distribution, F,C,E, curves and relation between them. Models for non-ideal reactions, dispersion model, tanks in series model, segregated flow model.

Practical: Minimum of **eight** experiments out of the following list should be performed.

1. Study of saponification of ethyl acetate reaction in batch reactor.
2. Determination of Arrhenius parameters.
3. Study of pseudo first order reaction. Acid catalyzed hydrolysis of methyl acetate
4. Study of saponification of ethyl acetate reaction in mixed flow reactor.
5. Study of saponification of ethyl acetate reaction in plug flow reactor

6. CSTRs in series.
7. RTD studies in PFR.
8. RTD studies in MFR.
9. RTD studies in Helical coil reactor.
10. CSTR followed by PFR.

References:

1. Chemical Reaction Engineering: Levenspile O.
2. Chemical Engineering Kinetics: Smith J.,
3. Elements of Chemical Reaction Engineering: H. Scott, Fogler.

309349: MASS TRANSFER –II

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week Practical : 4 Hours / Week	In Semester: 30 End Semester: 70 Practical: 50 **Total: 150** **Credits:5**

Unit 1: Distillation **7 Hrs**

Distillation principle, vapour-liquid equilibria for ideal and non-ideal systems, ideal solutions, positive and negative deviations from ideality, relative volatility, binary and multicomponent systems, methods of distillation - differential , flash, azeotropic, extractive, low pressure, steam distillation, batch rectification.

Unit 2: Continuous Rectification **7 Hrs**

Continuous rectification for binary system, multistage (tray) towers, packed towers for distillation, reboilers, distillation column internals, Lewis Sorrel, McCabe Thiele, and Ponchon-Savarit methods for multistage operations, tray efficiencies, concept of reflux, minimum reflux ratio, optimum reflux, total reflux, Fenske's equation, use of open steam, Partial and total Condensers, cold reflux, Fenske Underwood equation, concept of multi component distillation.

Unit 3: Liquid-Liquid Extraction **7 Hrs**

Ternary liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, x – y coordinates and solvent free basis, Continuous counter current extraction with reflux, total reflux, stage efficiency, continuous contact extraction in packed towers, HTU and NTU concept, types of extractors – stage type and differential type.

Unit 4: Solid-Liquid Extraction (Leaching) **7 Hrs**

Leaching equipment-continuous counter current leaching, ideal stage equilibrium, operating time, constant and variable underflow, number of ideal stages, stage efficiencies, calculation of single stage and multistage leaching processes.

Unit 5: Adsorption and Ion Exchange **7 Hrs**

Adsorption – Basic principle and equilibria in adsorption, types of adsorption-physical and chemical adsorption, break through curve, adsorption hysteresis, calculations of single stage, multistage adsorption, rate of adsorption in fixed bed, adsorption Isotherms-Langmuir and Freundlich, Introduction to pressure swing adsorption (PSA), and temperature swing adsorption (TSA). Ion Exchange: principles of ion exchange, techniques and applications, equilibria and rate of ion exchange, equipment's.

Unit 6: Crystallisation & Novel Techniques **7 Hrs**

Principle of crystallization, rate of crystal growth, size distribution, solubility curves, Mier's supersaturation theory, material balance, enthalpy balances, calculation of yield, equipments.

Introduction to membrane separation techniques: ultra filtration, nanofiltration, reverse osmosis, types of membranes and membrane modules, fluxes and driving forces in membrane separation processes.

Practical:

Minimum 10 practical's to be performed out of the following list.

1. Simple Distillation
2. Total Reflux
3. Steam Distillation
4. Vapour liquid equilibrium
5. Liquid-liquid equilibrium for ternary system
6. Liquid – Liquid Extraction (single stage and multistage)
7. Characterization of Spray Extraction Column
8. York Schibel Column
9. Distillation using Sieve Plate, Bubble Cap Column
10. Batch/ Continuous Leaching
11. Process of Crystallization and its Characteristics
12. Batch Crystallization
13. Ion Exchange
14. Adsorption

References:

1. Treybal R.E. "Mass Transfer Operation"
2. Richardson J. F. and Coulson J.M. "Chemical Engineering", Vol. I , II
3. McCabe and Smith, 'Unit Operations in Chemical Engineering" 4. Henley E. J. and Seader H.K. "Stage wise Process Design" , McGraw Hill
5. Smith B.D., "Design of Equilibrium Stage Process".
6. Foust A.S., "Principles of Unit Operations"
7. King C. J. "Separation Processes", McGraw Hill A.L. Lyderson, "Mass Transfer in Engineering Practices", John Wiley

309350: Transport Phenomena

Scheme:	Examination Scheme:
Lectures : 3 Hours / Week Tutorial: 2 Hrs/ Week	In Semester: 30 End Semester: 70 TW : 25 **Total: 125** **Credits: 4**

Unit 1: Momentum Transport **7 Hrs**

Importance of transport phenomena, analogous nature of transfer process, introduction of viscosity and mechanism of momentum transport: Newton's law of viscosity, Newtonian & Non-Newtonian fluids, pressure and temperature dependence of viscosity, theory of viscosity of gases and liquids. Velocity distribution in laminar flow: Shell momentum balances of - a) Flow of falling film b) Flow through the circular tube c) Flow through an annulus d) Flow in a narrow slit e) Adjacent flow of two immiscible fluids

Unit 2: Energy Transport **7 Hrs**

The introduction of thermal conductivity and mechanism of energy transport: Fourier's law of heat conduction, temperature and pressure dependence of thermal conductivity in gases and liquids.

Temperature distribution in solids and in laminar flow & numerical problems - a) Shell energy balance, boundary conditions b) Heat conduction with electrical heat source c) Heat conduction with a nuclear heat source d) Heat conduction with a viscous heat source e) Heat conduction with a chemical heat source f) Heat conduction with variable thermal conductivity g) Forced and free convection h) Heat conduction in a cooling fin

Unit 3: Mass Transport **7 Hrs**

Introduction of diffusivity and mechanism of mass transport: Definitions of concentrations, velocities and mass fluxes, Fick's law of diffusion, temperature and pressure dependence of mass diffusivity.

Concentration distribution in solids and in laminar flow & numerical problems - a) Shell mass balances, boundary conditions b) Diffusion through stagnant gas film c) Diffusion with heterogeneous chemical reaction d) Diffusion with homogeneous chemical reaction e) Diffusion through Pyrex tube, leaching etc.

Unit 4: Unsteady Momentum Transport **7 Hrs**

Equations of change for isothermal system -

a) The equation of continuity b) The equation of motion c) Equation of change in curvilinear coordinate systems d) Use of equation of change to set up steady flow problem e) Equation of mechanical energy f) Dimensional analysis of equation of change

Unit 5: Interphase transport in isothermal system **7 Hrs**

Interphase transport - a) Defining friction factors b) Friction factors for flow in tube, around spheres & packed column. Macroscopic balances for Isothermal systems - a) The macroscopic mass, momentum and mechanical energy balances b) Sudden enlargement and liquid-liquid ejector c) Semi empirical expressions for Reynolds stresses

Unit 6: Simultaneous & Analogy momentum, heat and mass transfer **7 Hrs**

Interphase transport in multi component system -

a) Definition of binary mass transfer coefficient in one phase b) Co-relation of binary mass transfer coefficient in one phase at low mass transfer rates c) Co-relation of binary mass transfer coefficient in two phases at low mass transfer rates d) Definition of transfer coefficient for high mass transfer rates Reynolds analogy, Prandtl's analogy, Chilton and Colburn analogy & Martinnelli's analogy.

References

1. Transport Phenomena, Bird R. B., Stewart and Lightfoot, John Wiley & Sons

2. Analysis heat and mass transfer, Eckert Erg and Brake R. M.

3. Fundamentals of momentum, heat and mass transfer, James Welty, Charles Wicks

4. Energy Mass and Momentum transport phenomena in continua", Slattery J. C.

309351: Elective-II

A. Energy Conservation in Chemical Process Industries

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit I: Energy Scenario **7 Hrs**

Classification of energy sources, commercial and noncommercial energy, energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario. energy and environment, air pollution, climate change, energy security, energy conservation and its importance, energy strategy for the future, energy conservation act-2001 and its features. Applications of renewable energy sources.

Unit II: Energy Management and Audit **7 Hrs**

Definition, energy audit – need, types of energy audit, energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use requirement maximizing system efficiencies, optimizing the input requirements, fuel and energy substitution, energy audit instruments, role, responsibilities and duties of energy manager.

Unit III: Energy Available for Industrial Use **7 Hrs**

Introduction, methodology for forecasting industrial energy supply and demand. New energy technologies and conservation, motivation of implementing conservation measures, evaluating costs and benefits of conservation measures.

Unit IV: Management and Organization of Energy Conservation Programs **7 Hrs**

Human aspect of energy conservation, involvement tree, elements of energy management program, romoting energy conservation, program planning, setting goals, setting priorities, allocation of resources, scheduling, measuring, monitoring and reporting, organization of energy conservation programs, plant level organization, division level organization, corporate level organization.

Unit V: Guidelines for Improving Process Operations for Energy Conservation **7 Hrs**

Energy conservation checklist, potential energy conservation in boilers, chilled water plants and central air – conditioning system, compressors and fans, heat pumps and cooling systems, water heaters and coolers, lighting systems, motors and transformers, mixing vessels, heat exchangers, evaporators, distillations, housekeeping.

Unit VI: Case Studies –Waste - Minimization and Resource Conservation. 7 Hrs

Make detail study report for dairy industry, sugar industry, distilleries, fertilizer industry, food industry, cement, and petroleum. These must include-importance of waste minimization and its classification, housekeeping, process change, recycling, product modification, waste minimization methodology steps, benefits of waste minimization.

Reference Books:

1. Industrial Energy Management and Utilization, Larry C. Witte, Philip S. Schmidt, Davis R. Brown. 1988

2. Handbook of Industrial Energy Conservation, S. David HU.

3. Energy Engineering and Management- Amlan Chakrabarti, PHI Learning-2011.

4. Guide book for National Certification Examination for Energy Managers and Energy Auditors- Book 1,2,3 and 4. Bureau of Energy Efficiency (BEE)

5. Energy Conservation in the Process Industries- W. F. Kenny, Academic Press Inc., 1984

6. Energy Conservation in the Chemical and Process Industries, Colin D. Grant, the Institution of Chemical Engineers. 1979

7. Solar Engineering of Thermal Processes, John A. Duffie and William A. Beckman, 3rd Edition-2006

309351: Elective-II

B. Process Instrumentation and Control

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit 1: Fundamentals of Process Instrumentation **7 Hrs**

Need and scope of process instrumentation, classification of process variables, measurement problem analysis, basic measurement terms, Functional elements of instruments, static and dynamic characteristics of measuring instruments (zeroth, first, and second-order instruments/ systems), measurement system configuration, transducer elements (types and classification). Intermediate elements: instrument amplifiers, compensators, differential and integrator elements, signal conditioners (signal generation and processing), filtering and signal analysis, data acquisition and conversion (ADC, DAC), digital signal transmission and processing (serial communication, telemetry), indicating and recording elements.

Unit 2: Temperature measuring instruments **7 Hrs**

Introduction, classification, temperature scales (units), mechanical temperature sensor (filled system thermometers, expansion thermometers), electrical temperature sensors (RTD, thermistors, thermocouples), radiation sensors (optical and radiation), solid-state sensors, quartz sensors, calibration methods (comparison and fixed point).

Unit 3: Pressure and strain measuring instruments **7 Hrs**

Introduction, classification, low, medium, and high pressure measuring instruments, pressure scales (units), manometers, elastic element pressure gauges with pressure equations (using bourdon tube, diaphragms, capsule, and bellows), transduction/ electrical sensors with pressure equations (based on variable capacitance, resistance, and inductance/reluctance-LVDT), force- balance transducers along with mathematical equations, solid-state devices, thin-film transducers, digital transducers, piezoelectric transducers, vibrating element sensors, pressure multiplexer, calibration of pressure sensors using dead- weight tester, Mechanical, optical, and electrical strain gauges.

Unit 4: Level and Flow Measuring Instruments **7 Hrs**

Level measuring instruments: Introduction, classification, direct methods (point contact methods, sight or gauge glass methods, buoyancy methods using floats and displacers), indirect methods (hydrostatic pressure methods, capacitance methods, radiation methods, ultrasonic methods, weighing method, sonic methods), solid level measurement. Flow measuring instruments: Introduction, classification (rate of flow and total flow meters), pressure head- type flow meters (orifice plate, venturi tube, flow nozzle, pitot tube), variable- area flow meters (rotameters), electromagnetic, mechanical (positive displacement and turbine- type), anemometer, ultrasonic - type, vortex- flow type, thermal - type, laser anemometers, mass flow meters (cover mathematical treatment for all the sensors).

Unit 5: Instrumental Methods of Chemical Analysis **7 Hrs**

Introduction, classification, basic components of analytical instruments, measurements used Absorption and emission spectrometric methods: ultraviolet (UV), visible, and infrared (IR) spectroscopy, atomic absorption spectroscopy (AAS), mass spectroscopy, Refractometry Chromatographic methods: gas chromatography (GC), liquid chromatography (LC), high performance liquid chromatography (HPLC). Electrochemical methods: measurement of pH, colourimetric, conductometric, potentiometric, Process instruments and automatic on-line analysis

Unit 6: Fundamentals of Process Dynamics **7 Hrs**

Introduction to process dynamics (PD), mathematical tools for process control (laplace transform, complex numbers), ideal forcing functions, control-relevant theoretical process modeling, transfer function and state-space models, poles and zeros of transfer function and their effect on dynamic response, block diagram representation, studying dynamic behavior of linear time invariant (LTI) systems, dynamic behavior of pure gain, pure capacitive, first order, second-order systems, dead time systems (derive differential equation model, transfer function, response to standard test signals and response characteristics along with physical examples), process identification using step response data, Introduction to feedback control system (FBCS), Introduction to ON-OFF, P, PI, PD, PID controllers.

References:

1. Instrument Engineers' Handbook (Process Measurement)- Bella G. Liptak, Elsevier
2. Instrument Engineers' Handbook (Process Control)- Bella G. Liptak, Elsevier
3. Instrumentation devices and systems- Rangan, Sharma, Mani, Tata McGraw Hill Publishing Co. Ltd.
4. Instrumental methods of analysis – Willard, Merritt, Dean, Settle, CBS Publishers and Distributors
5. Instrumental approach to Chemical Analysis- Shrivastava, Jain, S. Chand and Co.
6. Handbook of Analytical Instruments- Khandpur, Tata McGraw Hill Publishing Co. Ltd.
7. Process Control- Bequette, PHI publications
8. Chemical process control- Stephanopoulos, PHI publications
9. Process Dynamics and Control- Seborg, Edgar, Mellichamp- John Wiley and sons Inc.

309351: Elective-II

C. Corrosion Engineering

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit I: **7 Hrs**

Introduction and Scope, Corrosion: Definition, wet and dry corrosion, mechanism, electrochemical principles and aspects of corrosion, Faradays laws, specific conduction, specific resistance, transport no. mobility etc. various forms of corrosion, a brief review of corrosion rate expressions. Thermodynamic aspects of corrosion, equlibrium potential, Narnst equation for electrode potential. EMF series, overvoltage, application of Nernst equation to corrosion reactions, calculation of corrosion rates

Unit II: **7 Hrs**

Polarisation and Corrosion Potentials, reference electrodes for corrosion measurements, types of polarisation, concentration, activation and resistance polarisations, Tafel equation, Tafe constant, Evans Diagrams. Anodic control, cathodic control, mixed control. Pourbaix-diagram for Fe -H2O system.

Unit III: **7 Hrs**

Galvanic corrosion, uniform attack, pitting corrosion, dezincification, cavitation, erosion, fretting corrosion, intergranular and stress corrosion cracking. Remedial measures for the above.

Unit IV: **7 Hrs**

High temperature oxidation, Pilling Bedworth ratio, mechanisms of Oxidation, corrosion, testing procedures and evaluation: Corrosion of iron and steel in aqueous media, Effect of velocity, temperature and composition of media.

Unit V: **7 Hrs**

Prevention techniques, modification of the material by alloying, appropriate heat treatment. Chemical and Mechanical methods of surface treatment coatings - metallic, non-metallic linings, cathodic protection, passivity and anodic protection.

Reference Books:

1. Corrosion Engineering by Fontana and Greene, McGraw-Hill.
2. Corrosion and Corrosion Control, H.H. Uhllg, Wiley.
3. An introduction to Electrochemistry by Samuel Glasstone, Affiliated East West Press Private, Limited.

309351: Elective-II

D. Artificial intelligence and Data Science

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 Hours / Week	In Semester: 30 End Semester: 70 **Total: 100** **Credits: 3**

Unit I: Introduction, Scope, historical perspective; Implication of AI applied to problems in engineering analysis and design. **7 Hrs**

Unit II: Formal concepts in design, knowledge representation and data bases; Coupled symbolic and numerical computation; Qualitative reasoning, uncertainly, truth maintenance; integrated compute aided engineering. **7 Hrs**

Unit III: Knowledge based process control; Adaptive and learning systems; Applications of Neural Networks; Fuzzy logic and genetic algorithms; AI oriented languages and architectures. **7 Hrs**

Unit IV: Expert systems design and development; ES tools and techniques Applications in various chemical and bio – Chemical processes. **7 Hrs**

Unit V: Logic and Reasoning Knowledge Based Reasoning: Agents, Facets of Knowledge. Logic and Inferences: Formal Logic, Propositional and First Order Logic, Resolution in Propositional and First Order Logic, Deductive Retrieval, Backward Chaining, Second order Logic. **7 Hrs**

Unit VI: Problem Decomposition and Planning Problem Decomposition: Goal Trees, Rule Based Systems, Rule Based Expert Systems. Planning: STRIPS, Forward and Backward State Space Planning, Goal Stack Planning, Plan Space Planning, A Unified Framework for Planning. **7 Hrs**

References:

1. Venkat Venkatasubramanian, 2019, the Promise of Artificial Intelligence in Chemical Engineering: Is It Here, Finally?, AIChE, Vol. 65, No. 2
2. Zeinab Hajjar, Shokoufe Tayyebi and Mohammad Hosein Eghbal Ahmadi, 2018, Application of AI in Chemical Engineering.
3. Eghbal-Ahmadi M-H, Zaerpour M, Daneshpayeh M, Mostoui N. Optimization of fluidized bed reactor of Oxidative coupling of methane. International Journal of Chemical Reactor Engineering. 2012; 10:1-21
4. Araromi DO, Sonibare JA, Emuoyibofarhe JO. Fuzzy identification of reactive distillation for acetic acid recovery from waste water. Journal of Environmental Chemical Engineering. 2014; 2:1394-1403
5. Shih-Bo Hung and Ming-Jer Lee, 2006, Control of Different Reactive Distillation Configurations, AIChE,

Vol. 52, No. 4

6. Nilsson Nils J , “Artificial Intelligence: A new Synthesis, Morgan Kaufmann Publishers Inc. San Francisco, CA, ISBN: 978-1-55-860467-4 2.
7. Patrick Henry Winston, “Artificial Intelligence”, Addison-Wesley Publishing Company, ISBN: 0-201-53377-4 3.
8. Andries P. Engelbrecht-Computational Intelligence: An Introduction, 2nd Edition-Wiley India- ISBN: 978-0-470-51250-0

309352: Internship

Teaching Scheme:	Examination Scheme:
Internship : 4 Hours / Week	Total: 100 Credits: 4

The T&P cell will arrange internship for students in industries/organization after second, fourth and six/seventh semester(s) or as per AICTE/ affiliating University guidelines. Institutions may also device online system for arranging &managing internships. The general procedure for arranging internship is given below:

- **Step 1: Request Letter/ Email from the office of Training & Placement cell** of the college should go to industry to allot various slots of 4-6 weeks during summer vacation as internship periods for the students. Students request letter/profile/ interest areas may be submitted to industries for their willingness for providing the training. (Sample attached)
- **Step 2: Industry will confirm the training slots** and the number of seats allocated for internships via Confirmation Letter/ Email. In case the students arrange the training themselves the confirmation letter will be submitted by the students in the office of Training & Placement through concerned department. Based on the number of slots agreed to by the Industry, TPO will allocate the students to the Industry. In addition, the internship slots may be conveyed through Telephonic or Written Communication (by Fax, Email, etc.) by the TPO or other members of the T&P cell / Faculty members who are particularly looking after the Final/Summer Internship of the students.
- **Step 3: Students on joining Training** at the concerned Industry / Organization, submit the Joining Report/ Letters / Email.
- **Step 4: Students undergo industrial training** at the concerned Industry / Organization. In-between Faculty Member(s) evaluate(s) the performance of students once/twice by visiting the Industry/Organization and Evaluation Report of the students is submitted in department office/TPO with the consent of Industry persons/ Trainers. (Sample Attached)
- **Step 5: Students will submit training report** after completion of internship.
- **Step 6: Training Certificate** to be obtained from industry.
- **Step 7: List of students** who have completed their internship successfully will be issued by Training and Placement Cell.

PROCEDURES / FORMATS FOR ORGANIZING INTERNSHIPS

FORMAT1. STUDENT INTERNSHIP PROGRAM APPLICATION

Complete and submit to the TPO/ Internship Program Coordinator. Type or write clearly.

1. Student Name:		
2. Campus Address:		Phone:
3. Home Address:		Phone:
3a. Student email address:		

4. Academic Concentration		5. Internship Semester:______________Year.	
6. Overall GPA:			
9. Internship Preferences			
	Location	Core Area	Company/ institution
Preferance-1			
Preferance-2			
Preferance-3			
Faculty mentor Signature:_________________________________Date_____________. Signature confirms that the student has attended the internship orientation and has met all paperwork and process requirements to participate in the internship program, and has received approval from his/her Advisor..			
Student Signature:____Date____________. Signature confirms that the student agrees to the terms, conditions, and requirements of the Internship Program			

FORMAT 2: REQUEST LETTER FROM INSTITUTE TO INTERNSHIP PROVIDER

To

The General Manager (HR)

....

....

Subject: REQUEST FOR 04/06 WEEKS INDUSTRIAL TRAINING of M.Tech/4 years Degree Programme,

Dear Sir,

Our Students have undergone internship training in your esteemed Organization in the previous years. I acknowledge the help and the support extended to our students during training in previous years.

/ (For first time industry) You must be aware that AICTE has made internship mandatory for all technical education students.

In view of the above, I request your good self to allow our following__________________________students for practical raining in your esteemed organization. Kindly accord your permission and give at least one-week time for students to join training after confirmation.

S. No.	Name	Roll No.	Year	Discipline

If vacancies exist, kindly do plan for Campus/Off Campus Interview for__________________batch passing out students in above branches. CHECK THIS

A line of confirmation will be highly appreciated.

With warm regards,

Yours sincerely,

Training & Placement

FORMAT 3: RELIEVING LETTER OF STUDENT

To

....

....

Subject: Relieving letter of student and Industry. Dear

Sir,

Kindly refer your letter/e-mail dated.............................. on the above cited subject. As permitted by your good self the following students will undergo Industrial Internship in your esteemed organization under your sole guidance & directions:

S.No.	Name of Students	Roll No.	Branch

This training being an essential part of the curriculum, the following guidelines have been prescribed in the curriculum for the training. You are therefore, requested to please issue following guidelines to the concerned manager/Industrial Supervisor.

1. Internship schedule may be prepared and a copy of the same may be sent to us.
2. Each student is required to prepare Internship diary and report.
3. Kindly check the Internship diary of the student daily.
4. Issue instruction regarding working hours during training and maintenance of the attendance record.

You are requested to evaluate the student's performance on the basis of grading i.e. Excellent, Very Good, Satisfactory and Non Satisfactory on the below mentioned factors. The performance report may please be forwarded to the undersigned on completion of training in sealed envelope.

S.No.	Name of Students	Evaluation Ranking

a	Attendance and general behaviour	
b	Relation with workers and supervisors	
c	Initiative and efforts in learning	
d	Knowledge and skills improvement	
e	Contribution to the organization	

Your efforts in this regard will positively enhance knowledge and practical skills of the students, your cooperation will be highly appreciated and we shall feel obliged.

The students will abide by the rules and regulation of the organization and will maintain a proper discipline with keen interest during their Internship. The students will report to you on dated... along with a copy of this letter.

Yours sincerely,

Training & Placement Officer

FORMAT 4: STUDENT'S DAILY DIARY/ DAILY LOG

<table>
<tr><td colspan="2">DAY-1</td><td>DATE</td><td colspan="2"></td></tr>
<tr><td>Time of arrival</td><td></td><td>Time of Departure</td><td></td><td>Remarks</td></tr>
<tr><td>Deptt./Division</td><td></td><td>Name of finished Product</td><td colspan="2"></td></tr>
<tr><td rowspan="3">Name of HOD/ Supervisor With e-mail id</td><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td colspan="2">Main points of the day</td><td colspan="3"></td></tr>
</table>

Signature of Industry Supervisor

ORMAT 5: SUPERVISOR EVALUATION OF INTERN

Student Name:____Date:____________________

Work Supervisor:____Title:___________________

Company/Organization:____

Internship Address: ____

Dates of Internship: From_________________________________To_______________________________________

Please evaluate your intern by indicating the frequency with which you observed the following behaviors:

Parameters	Needs improvement	Satisfactory	Good	Excellent

Behaviors				
Performs in a dependable manner				
Cooperates with co-workers and supervisors				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/originality				
Analyzes problems effectively				
Is self-reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives a professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student intern (circle one):

(Needs improvement/ Satisfactory/____________________Good/______________Excellent)

Additional comments, if any:

Signature of Industry supervisor________________________HR Manager __________________________

FORMAT 6: STUDENT FEEDBACK OF INTERNSHIP (TO BE FILLED BY STUDENTS AFTER INTERNSHIP COMPLETION)

Student Name: ____ Date:________________________________

Industrial Supervisor: __________________________________ Title:________________________________

Supervisor Email: ______________________________________ Internship is:________Paid___Unpaid__________

Company/Organization: ____

Internship Address:____

Faculty Coordinator: _____________________________________ Department: ___________________________

Dates of Internship: From _________________________________ To ___________________________________

Please fill out the above in full detail

Give a brief description of your internship work (title and tasks for which you were responsible): Was your internship experience related to your major area of study?

_______________Yes, to a large degree__________________Yes, to a slight degree________________No, not related at all

Indicate the degree to which you agree or disagree with the following statements.

This experience has:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Given me the opportunity to explore a career field					
Allowed me to apply classroom theory to practice					
Helped me develop my decision-making and problem-solving skills					
Expanded my knowledge about the work world prior to permanent employment					
Helped me develop my written and oral communication skills					
Provided a chance to use leadership skills (influence others, develop ideas with others, stimulate decision-making and action)					
This experience has:	Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
Expanded my sensitivity to the ethical implications of the work involved					

Made it possible for me to be more confident in new situations					
Given me a chance to improve my interpersonal skills					
Helped me learn to handle responsibility and use my time wisely					
Helped me discover new aspects of myself that I didn't know existed before					
Helped me develop new interests and abilities					
Helped me clarify my career goals					
Provided me with contacts which may lead to future employment					
Allowed me to acquire information and/ or use equipment not available at my Institute					

In the Institute internship program, faculty members are expected to be mentors for students. Do you feel that your faculty coordinator served such a function? Why or why not?

How well were you able to accomplish the initial goals, tasks and new skills that were set down in your learning contract? In what ways were you able to take a new direction or expand beyond your contract? Why were some goals not accomplished adequately?

In what areas did you most develop and improve?

What has been the most significant accomplishment or satisfying moment of your internship? What did you

dislike about the internship?

Considering your overall experience, how would you rate this internship? (Circle one). (Satisfactory/

Good/ Excellent)

Give suggestions as to how your internship experience could have been improved. (Could you have handled added responsibility? Would you have liked more discussions with your professor concerning your internship? Was closer supervision needed? Was more of an orientation required.

FORMAT 7 : PROFORMA FOR EVALUTION OF INTERNSHIP BY INSTITUTE

DEPARTMENT OF TRAINING AND PLACEMENT

Ph.____________________Fax____________________Email______________________________________

*Evaluation (I)*____

1. Name of Student____Mob. No. ____________________
2. College Roll No.____University Roll No. ______________
3. Branch/Semester____Period of Training_______________
4. Home Address with contact No.____
5. Address of Training Site: ____
6. Address of Training Providing Agency:____
7. Name/Designation of Training In-charge ____
8. Type of Work____
9. Date of Evaluation ____
   a) Attendance: _ (Satisfactory/ Good/ Excellent)
   b) Practical Work: (Satisfactory/ Good/ Excellent
   c) Faculty's Evaluation: _ (Satisfactory/ Good/Excellent)
   d) Evaluation of Industry:______(Satisfactory/ Good/ Excellent)

Overall grade: (Satisfactory/ Good/ Excellent)

Signature of Faculty Mentor *Signature of Internship Supervisor (Industry)*

With date and stamp

***Photocopy of the attendance record duly attested by the training in-charge should be attached with the evaluation Proforma**

FORMAT 8: INTERNSHIP EVALUATION REPORT

(For 4 years Degree Programme)

Name & Address of Organization

____

____

____

Sr. No.	Name of Student	Roll No.	Marks to be awarded by			OVER ALL GRADE
			Punctuality Grade (Satisfactory/ Good/ Excellent)	Maintenance of Daily Diary Grade (Satisfactory/ Good/ Excellent)	Skill Test Grade (Satisfactory/ Good/ Excellent)	

FORMAT 9: ATTENDANCE SHEET

(For 4 years Degree Programme)

Name & Address of Organization

____

____

____

Name of Student		
Roll. No		
Name of Course		
Date of Commencement of Trg.:		
Date of Completion of Training:		

Initials of the student

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

Note :

1. Attendance Sheet should remain affixed in Daily Training Diary. **Do not remove or tear it off.**
2. Student should sign/initial in the attendance column. Do not mark 'P'
3. Holidays should be marked in **Red Ink** in attendance column. Absent should be marked as **'A' in Red Ink.**

Signature of Company internship supervisor with company stamp/ seal

(Name____) Contact No.

Savitribai Phule Pune University

Structure and Syllabus
BE (Chemical Engineering)
Course- 2019
W.E.F. 2022-2023

Savitribai Phule Pune University

Final Year of Chemical Engineering (2019 Course)

(With effect from Academic Year 2022-23)

Semester VII

Course Code	Course Name	Teaching Scheme (Hours/week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral\Pre	Total	Lecture	Practical	Tutorial	Total
409341	Process Dynamics and Control	03	02	-	30	70	-	50	-	150	3	1	-	4
409342	Chemical Reaction Engineering- II	03	-	-	30	70	-	-	-	100	3	-	-	3
409343	Chemical Engineering Design	03	02	-	30	70	-	-	50	150	3	1	-	4
409344	Elective-III	03	-	-	30	70	-	-	-	100	3	-	-	3
409345	Elective-IV	03	-	-	30	70	-	-	-	100	3	-	-	3
409346	Computer Aided Chemical Engineering- II	-	02	-	-	-	50	-	-	50	-	1	-	1
409347	Project Stage I	-	04	-	-	-	50	-	-	50	-	2	-	2
										Total Credit	**15**	**05**	**-**	**20**
	Total	**15**	**10**	**-**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**05**	**-**	**20**
409348	Audit Course 7										**Grade**			

Elective-III (409344)	**Elective IV (409345)**
409344(A)Environmental Engineering 409344(B) Membrane Technology 409344(C) Industrial Piping 409344(D) Petroleum Refining	409344 (A) Chemical Process Synthesis 409344(B) Industrial Management & Entrepreneurship 409344 (C) Green Technology 409344 (D) Advance Separation Processes

409348 Audit Course 7(AC7) Options:

AC7- I MOOC/NPTEL- Learn New Skills

Savitribai Phule Pune University

Final Year of Chemical Engineering (2019 Course)

(With effect from Academic Year 2022-23)

Semester VIII

Course Code	Course Name	Teaching Scheme (Hours/week)			Examination Scheme and Marks						Credit Scheme			
		Lecture	Practical	Tutorial	Mid-Sem	End-Sem	Term work	Practical	Oral/Pre	Total	Lecture	Practical	Tutorial	Total
409349	Process Modeling and Simulation	03	02	-	30	70	25	-	50	175	03	1		04
409350	Process Engineering Costing & Plant Design	03	02	-	30	70	25	-	50	175	03	1		04
419351	Elective-V	03	-	-	30	70	-	-	-	100	03			03
419352	Elective-VI	03	-	-	30	70	-	-	-	100	03			03
419353	Project Phase- II	-	12	-	-	-	100	-	50	150		06		06
										Total Credit	**12**	**08**	**-**	**20**
	Total	**12**	**14**	**-**	**120**	**280**	**150**	**-**	**150**	**700**	**12**	**08**	**-**	**20**
409354	Audit Course 8										**Grade**			

Elective V	**Elective VI**
409351(A) Energy Audit and Conservation	409352(A) Catalysis
409351(B) Chemical Process Safety	409352(B) Nanotechnology
409351(C) Computational Fluid Dynamics	409352(C) Fuel Cell Technology
409351(D) Advanced Materials	409352(D) Petrochemical Engineering
409351 (E) Open Elective	409352 (E) Open Elective

Audit Course 8(AC8) Options:

AC8- I MOOC/NPTEL/- Learn New Skills

SEMESTER I

BE (Chemical Engineering)-2019
Course Code: 409341
Process Dynamics and Control
Credits: 3+1

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
Practical: 2 h / week	End Semester: 70
	PR: 50
	Total: 150

Course Outcomes:

CO1	Analyze dynamic behavior of different first order systems for given input.
CO2	Analyze dynamic behavior of different second order systems and select different types of controllers to analyze feedback control systems.
CO3	Determine stability of a feedback control systems by root locus method and set controller parameters by different controller tuning techniques.
CO4	Analyze frequency response of a process by Bode method and predict stability of a feedback control system.
CO5	Design control systems with multiple loops and application of computer in process control.

Unit I: Dynamic behavior of simple processes (6h)

Objectives of Chemical Process Control, Mathematical modeling of chemical processes, State variables and state equations, Input-Output model, Linearization of nonlinear systems, Types of Forcing functions, dead-time systems, First order systems/processes – Thermometer, Liquid level tank, Liquid level tank with constant outlet (pure capacitive), isothermal and non-isothermal CSTR, Dynamic response of first order system to impulse and step inputs, basic concepts of MIMO systems.

Unit II: Design of single-loop feedback control systems (7h)

Second order systems/processes – Damped vibrator, Interacting and Non-interacting systems, Step response of second order system, Characteristics of under-damped system. Classical controllers – P, PI, PD, PID and ON- OFF controllers. Concept of feed-back control system, Servo & Regulatory problem, Block diagram reduction of complicated control systems, and Dynamic behavior of feed-back control processes.

Unit III: Stability Analysis of feed-back systems (7h)

Notion of stability, Characteristic equation, stability analysis of feedback control system using Routh-Hurwitz criteria, Root locus. Simple performance criteria – controller tuning with one-quarter decay ratio criteria, Time Integral performance criteria by ISE, IAE, ITAE, etc., selection of feed-back controller, Controller tuning using process reaction curve by Cohen-coon technique.

Unit IV: Frequency response analysis of linear processes **(7h)**

Response of first order system to sinusoidal input, Frequency response characteristics of general linear system, Bode diagrams - First order system, Second order system, Pure capacitive process, dead time system, P, PI, PD & PID, Bode stability criteria, Gain margin, Phase Margin, Nyquist Stability criteria, Ziegler Nicholes Tuning technique

Unit V: Design of complex control system **(7h)**

Design of controllers with difficult dynamics such as large time-delay systems, inverse-response systems. Analysis and design of control systems with multiple loops (cascade, selective, split range control systems) Analysis and design of advanced control systems (feed forward, ratio, adaptive and inferential control systems)

Unit VI: Digital and Computer- based Control Systems: **(6h)**

Sampling of continuous signals to discrete- time signals, reconstruction of continuous- time signals from discrete- time signals using hold elements, Digital approximation of classical controllers, Role of digital computer in process control as process interface for data acquisition and control, Centralized control systems, supervisory control systems (SCADA), microcomputer- based control systems (PLC, DCS), Plant wide control for plants involving compressor, Heat Exchanger, Adiabatic Plug Flow Reactor.

List of Experiments (minimum 8):

1. Dynamic response of liquid tank level system
2. Dynamic response of thermometer in oil bath thermo well system
3. Dynamic response of two interacting systems
4. Dynamic response of two non-interacting systems
5. Dynamic response of an On-off controller
6. Dynamic response of P, PI and PID controllers
7. Root locus analysis
8. Root locus analysis on software (Ex. MATLAB)
9. Bode plot on software (Ex. MATLAB)
10. PID control loop simulation for a first order process (Ex. SIMULINK)
11. Cascade control system
12. Heat exchanger control system

Reference Books:

1. Chemical Process Control, George Stephanopoulos, PHI publication,
2. Process System Analysis & Control, Donald R. Coughanour, Mc Graw Hill
3. Process Control – Modelling, Design & Control, B. Wayne Bequette, PHI Publication
4. Process Dynamics & Control, Dale E. Seaborg, Thomal F. Edgar, Dancan A. Mellichamp
5. Process Dynamics, Modeling & Control – Babatunde A. Ogunnaike, W. Harmon Ray, Oxford University Press Inc.
6. Computer Control of Processes – M. Chidambaram, Alpha Science International Ltd.
   Instrument Engineers Handbook (Process Control) –Bella G. Liptak, Elsevier

BE (Chemical Engineering)-2019
Course Code: 409342
Chemical Reaction Engineering II
Credits: 3

Teaching Scheme:	**Examination Scheme:**
Lectures: 3h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit I: Heterogeneous Reactions (6 h)

Types, rates, contacting patterns. Fluid-Particle reactions: Selection of model unreacted core model, progressive conversion model, Rate of reaction for shrinking spherical particles. Determination of rate controlling step, application to design, application to fluidized bed with entrainment.

Unit II: Fluid – Fluid Reaction (7 h)

Rate equation for reaction, kinetic regimes (case A to H), film conversion parameter, slurry reaction kinetics, aerobic fermentation, application to design (fast and slow reactions), mixer settler, Semi batch contacting pattern, reactive distillation and extractive reactions

Unit III: Catalysis and Adsorption (7 h)

Surface chemistry and adsorption, adsorption isotherms and rates of adsorption. Catalysis: Determination of surface area by BET method, void volume and solid density, pore-volume distribution, catalyst selection, preparation of catalyst and its deactivation, poisoning and regeneration, nature and mechanism of catalytic reactions.

Unit IV: Reaction and Diffusion in porous catalyst (7 h)

Gaseous diffusion in single cylindrical pore, diffusion in liquids, in porous catalyst, surface diffusion, mass transfer with reaction: effectiveness factor, experimental and calculated effectiveness factor, selectivity's for porous catalysts, rates for poisoned porous catalysts.

Unit V: Solid- catalyzed Reaction (7 h)

Rate equation (Film resistance, surface phenomenon, pore diffusion) experimental methods for finding rates, determining controlling resistances and rate equation, product distribution in multiple reactions.

Unit VI: Design of Heterogeneous Catalytic Reactors and Biochemical Reaction Systems (6h)

Fluidized bed reactor, isothermal and adiabatic fixed bed reactor, fluidized bed reactor, slurry reactor, enzyme fermentation: Michaelis–Menten (M-M) kinetics, inhibition by foreign substance.

Reference Books:

1) Chemical Reaction Engineering: Octave Levenspiel (2^{nd} & 3^{rd} Edition)
2) Chemical Engineering Kinetics: J. M. Smith (3^{rd} Edition)
3) Elements of Chemical Reaction Engineering: H. Scott Fogler (4^{th} Edition)
4) Heterogeneous Reactions: Analysis Examples and reactor Design. Vol.1 & 2- Doraiswamy L. K. and Sharma M. M.
5) An Introduction to Chemical Reaction Kinetics & Reactor Design - C.G.Hill.

BE (Chemical Engineering)-2019 Course
Code: 409343
Chemical Engineering Design
Credits: 3 + 1

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
Drawing: 2 h / week	End Semester: 70
	OR: 50
	Total: 150

Course Outcomes:

CO1	Develop the mechanical and process design of the plate distillation column.
CO2	Design the process and mechanical aspects of the packed bed distillation column.
CO3	Apply basic concepts, design calculations and materials of construction of the piping system
CO4	Differentiate the types and applications of the plant utilities required in the process industries
CO5	Identify the types of the maintenance and the process safety measures to be taken in the design and operation of the project

Unit 1: Agitators and Reaction vessels **6Hrs**

Study of various types of agitators, their selection, applications, baffling, agitator shaft diameter calculations which includes twisting moment, equivalent bending moment, power requirement calculations for agitation systems.

Reaction vessels: introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil, study and design of internal coil reaction vessels, heat transfer coefficients in coils.

Unit 2: Storage Vessels **7 Hrs**

Study of various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and non-volatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, Design of cylindrical storage vessels as per IS: 803-design of base plates, shell plates, roof plates, wind girders, curb angles for self-supporting and column supported roofs. Design of rectangular tanks as per IS: 804.Stresses in the shell of a tall vertical vessel, and period of vibration.

Vessel supports- introduction and classification of supports, design of skirt supports considering stresses due to dead weight, wind load, seismic load, design of base plate, skirt bearing plate, anchor bolts, bolting chairs and skirt shell plates Design of saddle supports, ring stiffeners.

Unit 3: Heat Exchangers **7 Hrs**

Shell and tube heat exchanger- General design considerations- LMTD correction factor, fluid allocation, fluid velocities, stream temperatures, pressure drop, shell side and tube side heat transfer coefficients, overall heat transfer coefficient, mechanical design of shell and tube heat exchanger thickness of shell and shell cover, channel cover, tube sheet, size and number of tie rods and spacers.

Design of double pipe heat exchanger. Plate heat exchanger: advantages, disadvantages, design procedure, temperature correction factor, heat transfer coefficients, pressure drop.

Evaporators: classification, criteria for selection, design of calendria type evaporator.

Unit 4: **Design of distillation column** **7 Hrs**

Design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors, and plate hydraulic design.

Unit 5: Design of Packed column **6Hrs**

Choices of plates or packing, packed column design procedure, packed bed height (distillation and absorption), HTU, Cornell's method, Onda's method, column diameter, column internals, wetting rates, column auxiliaries.

Unit 6: Piping Design **7 Hrs**

A brief revision covering friction factor, pressure drop for flow of non-compressible and compressible fluids, (Newtonian Fluids), pipe sizing, economic velocity. Pipe line networks and their analysis for flow in branches, restriction orifice sizing. Pipe supports, non-Newtonian fluids – types with examples, pressure drop calculations for non-Newtonian fluids. Pipe line design on fluid dynamic parameter. Design of pipeline for natural gas, Pipeline design for transportation of crude oil.

Term work: Process and Mechanical design and drawing of any five equipments from unit 1 to 6 which should include at least two sheets based on AUTOCAD/Autodesk or design software.

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, PergamonPress.

5. "Chemical Engineering volume 2" by J. M. Coulson, J. F. Richardson, and R. K. SinottPergamon Press.
6. "Applied Process Design for Chemical and Petrochemical Plants" vol 1 and 2, Ludwig E.E., GulfPublishing Company, Texas.
7. "Indian standards Institution" code for unfired pressure vessels, IS - 2825
8. "Chemical Process Equipment-Selection and design" Walas S.M. Butterworth Heinamen, McGraw Hill book company, New York
9. "Mass Transfer Operations" by Treyball R.E., McGraw Hill, New York.
10. Pipe Drafting and Design by Roy A Parisher& Robert A. Rhea, Gulf Professional Publishing, 2012.
11. Hydraulics and Fluid Mechanics by Modi and Seth, Standard Publishers Distributors.
12. "Process Design of Equipments" by S. D. Dawande, Central Techno Publication

BE (Chemical Engineering)-2019 Course
Code: 409344
Elective III
Credits: 3

409344: (A) Environmental Engineering

Teaching Scheme	**Examination Scheme**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Course Outcomes:

CO1	Classify types of pollutions and illustrate pollution laws and standards
CO2	Identify air Pollution-Sources, Effects and Measurement and apply Controlling Methods
CO3	Differentiate types, sources and effects of water pollutants in wastewater and determine Wastewater characteristics
CO4	Select and design the wastewater treatments to minimize water pollution
CO5	Apply tertiary wastewater Treatment and Solid Waste Management for its disposal

Unit I: Introduction **(6 h)**

An overview of environmental engineering, pollution of air, water and soil, impact of population growth on environment, environmental impact of thermal, hydro and nuclear energy, chemical pollution, solid wastes, prevention and control of environmental pollution, water and air pollution laws and standards, clean development mechanisms (CDM), Kyoto protocol.

Unit II: Air Pollution- Sources, Effects and Measurement **(7 h)**

Definition of air pollution, sources scales of concentration and classification of air pollutants. Effects of air pollutants on human health, plants, animals, materials, Economic effects of air pollution, sampling and measurement of air pollutants, air pollution control standards: WHO, BIS, MPCB, CPCB.

Unit III: Air Pollution Control Methods and Equipment **(7 h)**

Particulate pollution: cleaning methods, collection efficiency, particulate collection systems, Basic design and operating principles of settling chamber, cyclone separator, fabric filter, electrostatic precipitator. Operating principles of spray tower, centrifugal scrubber, venturi scrubber, selection of particulate collector. Gaseous pollution: Principles of control by absorption, adsorption, combustion or catalytic oxidation, removal of SOx, NOx. Numerical problems based on the theory.

Unit IV: **Water Pollution** **(7 h)**

Domestic and industrial wastewater, types, sources and effects of water pollutants. Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colour and odour, bacteriological quality, oxygen deficit, determination of BOD constants. Water quality standards: ICMR, WHO, MPCB and CPCB.

Unit V: Wastewater Treatment **(7 h)**

Principles of primary treatment and secondary treatment, process design and basic operating principles of activated sludge (suspended growth) process, sludge treatment and disposal, trickling filter, Moving Bed Bio film Reactor (MBBR). Advanced methods of waste water treatment: UASB, photo catalytic reactors, wet-air oxidation, Membrane Bioreactor (MBR) and biosorption.

Unit VI: Tertiary Water Treatment and Solid Waste Management **(6 h)**

Tertiary treatment: disinfection by chlorine, ozone and hydrogen peroxide, UV rays, recovery of materials from process effluents, micro-screening, biological nitrification and denitrification, granular medium filtration. Land Pollution: Sources and classification of solid wastes, disposal methods, incineration, composting, recovery and recycling.

Reference Books:

1. Rao C. S. “Environmental Pollution Control Engineering”, Wiley Eastern Publications.
2. Metcalf and Eddy “Wastewater Engineering”, Tata McGraw Hill Publishers.
3. Mahajan S.P. “Pollution Control in Process Industry”, Tata McGraw Hill Publishers
4. J.C. Mycock, John D. McKenna, Louis Theodore “Handbook of Air Pollution Control Engineering and Technology”.
5. Flagan R.C. and Seinfield J.H. “Fundamentals of Air Pollution Engineering” Prentice-Hall, Inc. , Englewood Cliffs, New Jersey.
6. Peavy H.S. and Rowe D.R. and Tchobanoglous G. “Environmental Engineering” McGraw-Hil International Ed., 1985,
7. Martin Crowford “Air Pollution Control theory” McGraw-Hill Inc.,US.
8. Stern “Air Pollution”, Vol.-I and Vol.-II, 2nd Edition, Academic Press, New York.
9. G. Kiely, Environmental Engineering, McGraw Hill 1997.

BE (Chemical Engineering)-2019 Course
Code: 409344
Elective III
Credits: 3

409344: (B) Membrane Technology

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit I: Introduction to membrane processes, membrane materials and their properties (6h)

Introduction: Objectives, classification, and selection criteria for industrial separation processes, historical background and introduction to membranes and membrane processes. Benefits and drawbacks of membrane processes over conventional separation processes. Definitions of membrane, types of membranes (isotropic, anisotropic) volume flux, retention, separation factor. Membrane materials and their properties: Types of polymeric materials used for membrane preparation, Factors affecting properties of polymers, membrane polymers (porous, nonporous, and inorganic membranes), thermal, mechanical and chemical stability of polymers, membrane characterization.

Unit II: Membranes and membrane modules (7h)

Introduction, preparation of isotropic (nonporous and microporous) and anisotropic membranes, choice of polymer, casting solution solvent, precipitation medium and casting solution modifiers, interfacial polymerization membranes, solution-coated composite membranes, repairing membrane defects, metal and ceramic membranes, carbon membranes, glass membranes, liquid membranes, hollow fiber membranes. Membrane modules: Introduction, plate and frame model, spiral wound module, tubular module, capillary module, hollow fiber model, vibrating and rotating modules, comparison and selection of module configurations.

Unit III: Transport theories in Membranes (7h)

Introduction, driving forces, transport through microporous and dense membranes, solution diffusion theory (for dialysis, RO, hyper filtration, gas separation, pervaporation membranes), structure-permeability relationships, diffusion coefficients, sorption coefficients, pore flow theory (for UF, MF membranes), Ferry-Rankin equation, surface and depth filters, Knudsen diffusion and surface diffusion through microporous membranes.

Unit IV: Concentration polarization and fouling of membranes (7h)

Introduction, boundary layer film model, concentration polymerization in liquid separation and gas separation processes, effect of cross-, co- and counter-flow arrangements, gel layer model, osmotic pressure model, methods of reducing concentration polarization (turbulence promoters), temperature polarization, membrane fouling, methods to reduce fouling, membrane cleaning.

Unit V: Applications of UF, MF, RO processes (6h)

Describe basic transport theory, membranes and materials used, membrane selectivity, concentration polarization and fouling, membrane modules, system designs (batch, continuous, multistep, and multistage) and applications for each process. Applications: RO-Desalination of brackish and sea water, getting ultrapure water, waste water treatment, NF, organic solvent separation. UF- Food industry (cheese production, clarification of fruit juice), separation of oil-water emulsions, process water and product recycling. MF-Sterile filtration of pharmaceuticals, sterilization of wine and beer, drinking water treatment,

Unit VI: Applications of GS, PV, and other membrane processes (7h)

Describe basic transport theory, membranes and materials, membrane selectivity, concentration polarization and fouling, membrane modules, system designs (batch, continuous, multistep, and multistage) and applications for each process. Applications of: GS- Hydrogen separations, oxygen/nitrogen separation, natural gas separations, CO_2 separations, vapor/gas separations, vapor/vapor separations, dehydration of air. PV- Solvent dehydration, water purifications, organic/organic separations. Electro dialysis: Brackish water desalination, salt recovery from seawater, electrode ionization, Carrier facilitated transport (coupled transport membranes, ELM) - Removal and recovery of metals from dilute solutions, CO_2/H_2S separation, olefin separation, oxygen/nitrogen separations. Thermally-driven membrane processes (membrane distillation), membrane contactors, electrically driven membrane processes (electrodialysis, membrane electrolysis), membrane reactors and bioreactors.

Reference Books:

1. Marcel Mulder, Basic Principles of Membrane Technology, Kluwer Academic Publications.
2. Coulson and Richardson's Chemical Engineering, Volume 2, Elsevier.
3. S.P. Nunes, and K.V. Peinemann, membrane Technology in the chemical industry, Wiley-VCH.
4. R. Rautanbach and R. Albrecht, Membrane Process, John Wiley & Sons.
5. R.Y.M. Huang, Perevoparation Membrane Separation Processes, Elsevier.
6. J.G. Crespo, K.W. Boddekes, Membrane Processes in Separation and Purification, Kluwer Academic Publications.
7. Larry Ricci and the staff of chemical engineering separation techniques, McGraw Hill publications.
8. Richard W. Baker, Membrane Technology and Applications, John Wiley & Sons, Ltd

BE (Chemical Engineering)-2019 Course
Code: 409344
Elective III
Credits: 3

409344: (C) Industrial Piping

Teaching Scheme:
Lectures: 3 h / week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Unit 1: Introduction: (6 Hrs)

Importance of piping in chemical industry, Pipes & Tubing, Classification of pipes, Pipe codes and specification. Pipe sizing, Schedule numbers, BWG, NPS. Desirable properties of piping materials, materials for low, normal & high temperature services, materials for corrosion resistance. Basic energy equation for flow, calculation of frictional losses, pressure drop for Newtonian & Non-Newtonian fluids. Calculation of pipe diameter, thickness, equivalent lengths, etc, single liquid lines, single gas &vapor lines, NPSH.

Unit 2: Pipe fittings: (7 Hrs)

Pipe fittings their advantages & disadvantages. Criteria for selection of pipe joints, pipe joints for similar and dissimilar material, valves expansion effects and methods for reducing them. Safety valves & other pressure relieving devices. Calculation of frictional losses, pressure drop for Newtonian & Non-Newtonian fluids.

Unit 3: Piping layout: (7 Hrs)

Piping layout piping diagrams, standard symbols & notations, types & design of pipe support, erection and maintenance of supporting, restraining and bracing systems. Fundamental considerations in pipe vibrations, types of vibrations, their prevention and control. Protection of pipe system such as cathode protection, painting, etc.

Unit 4: Piping design-1: (7 Hrs)

Pipeline design on fluid dynamics. Complex pipelines in series and parallel. Pipeline storage capacity. Piping design for two phase flow, dispersed flow. Slurry pipeline – design parameters, slurry rheology for homogeneous & heterogeneous slurries. Piping & components as gas expands – isothermal flow, adiabatic flow.

Unit 5: Piping design-2: (6 Hrs)

Design of pipeline for transportation of crude oil & for natural gas. Design of pipes in sea water. Empirical correlations for flow of oil, gasoline, hydrocarbons. Piping for cryogenic materials. Piping arrangements and factors considered in heat exchanger piping, reactor piping, process & storage vessel piping, reboiler piping, piping for compressor & pumps, utility piping.

Unit :6 Piping insulation: **(7 Hrs)**

Insulation for piping systems. Purpose of insulation. Insulation materials, their selection criteria, their important properties. Principles of heat transfer to the extent of application to heat loss/gain through bare pipe surfaces. Critical thickness of insulation, estimating thickness of insulation, optimum thickness of insulation.

Text Books:

1. Piping Design for process plants by H. F. Rase, John Wiley.
2. Process piping systems, ed" D. J.Deutsch, Chemical Engineering Magazine. McGraw Hill
3. Industrial Piping by Littleton C.T., McGraw Hill.
4. Process Design of Equipments, Dr.S.D.Dawande, Central Techno Publications.
5. Handbook of Piping Design, G.K. Sahu, New Age International Publisher.
6. Process Piping Design Vol. 1 and 2, R. Weaver, Gulf Publishing.

References Books:

1. Handbook of Piping Design, G.K. Sahu, New Age International Publisher.

BE (Chemical Engineering)-2019 Course
Code: 409344
Elective III
Credits: 3

409344: (D) Petroleum Refining

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	TW: 25
	Total: 100

Unit I: Petroleum Composition and Products (6h)
Origin, formation, composition & Exploration of petroleum, crude assay, overall refinery Flow, specifications of petroleum products such as LPG, Gasoline, Kerosene, Diesel, lube oil, etc. as per standards like ASTM, ISO, etc.

Unit II: Crude Oil Distillation (7h)
Pre-refining operations such as Settling, Moisture removal, Desalting, Storage, Heating through exchangers and pipe still heaters, Atmospheric distillation, Vacuum distillation

Unit III: Conversion Processes (7 h)
Significant conversion processes such as catalytic & thermal cracking, hydro-cracking, reforming and coking.

Unit IV: Lube oil and Bitumen (7h)
Lube oil production, Properties of lube oil, deasphalting, Solvent extraction, dewaxing, Finishing operations, Lube oil additives, Manufacture of Bitumen.

Unit V: Supporting Processes (7h)
Hydrogen Management: Production and recovery, Sulphur Recovery, Environmental Pollution aspects in refinery

Unit VI: Finishing Processes and Logistics (6h)
Blending, Additives, Storage of products, Transportation, Safety norms, Housekeeping, Marketing of petroleum and petroleum products

Seminar (TW): The term-work shall be based on technical report prepared by individual or small group (2-3) of students on studies in industrial applications (case studies) of petroleum refining processes. Students are expected to deliver seminar presentation using audio-visual techniques on the topic.

Reference Books:

1. Gary J H, Handwerk G E, ‘Petroleum refining technology and economics’, Marcel Dekker, Inc.
2. Speight J G, ‘The Chemistry and technology of petroleum’, CRC Press.
3. Myers, ‘Handbook of Petroleum Processing’, McGraw-Hill Education.

BE (Chemical Engineering)-2019 Course
Code: 409345
Elective IV
Credits: 3
409345: (A) Chemical Process Synthesis

Teaching Scheme:
Lectures: 3 hr / week

Examination Scheme:
In Semester : 30
End Semester : 70
Total: 100

Unit I: Introduction to Chemical Process Design (6h)
Introduction, approach to process development, development of new process, different considerations, development of particular process, overall process design, hierarchy of process design, onion model, approach to process design.

Unit II: Choice of Reactor (7h)
Reaction path, types of reaction systems, reactor performance, idealized reactor models, reactor concentration, temperature, pressure, phase, catalyst.

Unit III: Choice of Separator (7 h)
Separation of heterogeneous mixtures, separations of homogeneous mixtures, distillation, azeotropic distillation, absorption, evaporation, drying etc

Unit IV: Distillation Sequencing (7h)
Distillation sequencing using simple columns, heat integration of sequences of simple distillation columns, distillation sequencing using thermal coupling, optimization of reducible structure.

Unit V: Heat Exchanger Network And Utilities (7h)
Energy targets, composite curves, heat recovery pinch, threshold problems, problem table algorithm, process constraints, utility selection, furnaces, combined heat and power, integration of heat pump, integration of refrigeration cycles, overall heat exchanger network and utilities.

Unit VI: Safety And Health Considerations: (6 h)
Fire, explosion, toxic release, intensification of hazardous materials, attenuation of hazardous materials, quantitative measures of inherent safety, overall safety and health considerations.

Reference Books:

1. Chemical process design- Robin Smith, Wiley.
2. Conceptual design of chemical process-James Douglas, McGraw Hill Book Company.
3. Unit process in organic synthesis – P.H. Groggins, Tata McGraw Hill Publishing Company Ltd.
4. Dryden's Outline of Chemical Engineering, Rao and M Gopala, East-West Press.

BE (Chemical Engineering)-2019 Course
Code: 409345
Elective IV
Credits: 3

409345: (B) Industrial Management and Entrepreneurship

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 hr / week	In Semester : 30
	End Semesters: 70
	Total: 100

Unit I: The Entrepreneurial Development Perspective (6 h)

Concepts of Entrepreneurship Development, Evolution of the concept of Entrepreneur, Entrepreneur Vs. Entrepreneur, Entrepreneur Vs. Entrepreneurship, Entrepreneur Vs. Manager, Attributes and Characteristics of a successful Entrepreneur, Role of Entrepreneur in Indian economy and developing economies with reference to Self-Employment Development, Entrepreneurial Culture.

Unit II: Creating Entrepreneurial Venture and Project Management (7 h)

Business Planning Process, Environmental Analysis - Search and Scanning, Identifying problems and opportunities, Defining Business Idea, Basic Government Procedures to be complied with, Technical, Financial, Marketing, Personnel and Management Feasibility, Estimating and Financing funds requirement - Schemes offered by various commercial banks and financial institutions like IDBI, ICICI, SIDBI, SFCs, Venture Capital Funding.

Unit III: Entrepreneurship Development and Government (7 h)

Role of Central Government and State Government in promoting Entrepreneurship - Introduction to various incentives, subsidies and grants, Fiscal and Tax concessions available, Role of following agencies in the Entrepreneurship Development - District Industries Centers (DIC), Small Industries Service Institute (SISI), Entrepreneurship Development Institute of India (EDII), National Institute of Entrepreneurship & Small Business Development (NIESBUD), National Entrepreneurship Development Board (NEDB), Why do Entrepreneurs fail - The FOUR Entrepreneurial Pitfalls (Peter Drucker), Women Entrepreneurs: Reasons for Low / No Women Entrepreneurs, Role, Problems and Prospects. Case studies of Successful Entrepreneurial Ventures, Failed Entrepreneurial Ventures and Turnaround Ventures.

Unit IV: Management Theories and Managerial Work (7 h)

Stages of team development (Tuckman), Team role theory (Belbin), Management roles (Henry Mintzberg), Situational leadership (Blanchard), Hierarchy of needs (Maslow), Five competitive forces (Porter), Interview of mid / large cap industry professional (preferably MBA) to understand practical usage of any of these theories. Business communication, communication process, communication styles, and communication forms in organizations, fundamentals of business writing, patterns of business messages, report writing, public speaking and oral reporting, verbal and nonverbal communication, use of visual and presentation aides, and cultural and international dimensions of communication, Organization behavior.

Unit V: Project Management based on Microsoft Project (6 h)

Introduction, Project management concepts, Using Microsoft project, Start your plan, Adding resources to the model, Resource management & crashing, Resource rates & using calendars, Handling multiple projects, uncertain activity times, Tracking, Baseline & reports, Assignment – case study of a project involving various resources, timeline & costs, Business excellence through six sigma and kaizen.

Unit VI: Marketing Management (7 h)

Introduction to the basic concepts and principles of marketing, Consumer Behavior, Marketing Research, Product & Brand Management, Integrated Marketing Communications, Marketing Channels, International Marketing, Internet Marketing, Business-to-Business Marketing, Understanding the role of marketing in society and the firm, marketing concept, market segmentation, target marketing, demand estimation, product management, channels of distribution, promotion and pricing. Introduction to the concepts, principles, and techniques used in gathering, analyzing and interpreting the data for marketing decisions. The role of information in marketing decisions, research problem, formulation, research design methods, measurement and design of research instruments, sampling design, data collection methods, data analysis and presentation of research results.

Reference Books:

1. Entrepreneurship: New Venture Creation - David H. Holt, Prentice Hall PTR, 1992.
2. Entrepreneurship - Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, McGraw-Hill Education, 2013.
3. The Culture of Entrepreneurship - Brigitte Berger, Ics Press, 1991.
4. Project Management - K. Nagarajan, New Age International, 2004.
5. Dynamics of Entrepreneurship Development - Vasant Desai, Himalaya Publishing House, 2001.
6. Entrepreneurship Development**:** An Interdisciplinary Approach, S. G. Bhanushali, Himalaya Publishing House, 1987
7. Thought Leaders –ShrinivasPandit, Tata McGraw-Hill Education, 2002.
8. Entrepreneuring: The Ten Commandments for Building a Growth Company, Steven C. Brandt, Archipelago Pub., 1997.
9. Business Gurus Speak - S.N. Chary, 2002.
10. The Entrepreneurial Connection –Gurmit Narula, Tata Mc-Graw Hill.
11. Business Marketing Management: B2B, Michael Hutt, Thomas Speh, Cengage Learning, 2012.

BE (Chemical Engineering)-2019 Course
Code: 409345
Elective IV
Credits: 3

409345: (C) Green Technology

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 hr / week	In Semester : 30
	End Semesters : 70
	Total: 100

Unit 1: Principles and concepts of Green Chemistry: (6 Hrs)
Introduction, Sustainable Development and Green Chemistry, Atom Economy, Atom Economic Reactions, Rearrangement Reactions, Addition Reactions, Atom Un-economic Reactions, Substitution Reactions, Elimination Reactions, Wittig Reactions, Reducing Toxicity, Measuring Toxicity

Unit 2: Production, Problems and Prevention: (7 Hrs)
Introduction, Some Problems Caused by Waste, Sources of Waste from the Chemical Industry, The Cost of Waste, Waste Minimization Techniques, The Team Approach to Waste Minimization, Process Design for Waste Minimization, Minimizing Waste from Existing Processes, On-site Waste Treatment, Physical Treatment, Chemical Treatment, Bio-treatment Plants, Design for Degradation, Degradation and Surfactants, DDT, Polymers, Some Rules for Degradation, Polymer Recycling, Separation and Sorting, Incineration, Mechanical Recycling, Chemical Recycling to Monomers

Unit 3: Measuring and controlling environmental performance: (7 Hrs)
The Importance of Measurement, Lactic Acid Production, Safer Gasoline, Introduction to Life Cycle Assessment, Green Process Metrics, Environmental Management Systems, The European Eco-management and Audit Scheme, Eco-labels, Legislation, Integrated Pollution Prevention and Control. Catalysis and green chemistry: Introduction to Catalysis, Comparison of Catalyst Types, Heterogeneous Catalysts, Basics of Heterogeneous Catalysis, Zeolites and the Bulk Chemical Industry, Heterogeneous Catalysis in the Fine Chemical and Pharmaceutical Industries, Catalytic Converters, Homogeneous Catalysis, Transition Metal Catalysts with Phosphine Ligands, Greener Lewis Acids, Asymmetric Catalysis, Phase Transfer Catalysis, Hazard Reduction, C–C Bond Formation, Oxidation Using Hydrogen Peroxide, Bio-catalysis, Photocatalysis.

Unit 4: Organic solvents, Environmentally benign solutions: (7 Hrs)
Organic Solvents and Volatile Organic Compounds, Solvent-free Systems, Supercritical Fluids, Supercritical Carbon Dioxide, Supercritical Water, Water as a Reaction Solvent, Water-based Coatings, Ionic Liquids, Ionic Liquids as Catalysts, Ionic Liquids as Solvents, Fluorous Biphase Solvents. Renewable resources: Biomass as a Renewable Resource, Energy, Fossil Fuels, Energy from Biomass, Solar Power, Other Forms of Renewable Energy, Fuel Cells, Chemicals from Renewable Feedstock's, Chemicals from Fatty Acids, Polymers from Renewable Resources, Some Other Chemicals from Natural Resources, Alternative Economies, The Syngas Economy, The Biorefinery, Chemicals from renewable feed stocks.

Unit 5: Emerging Greener technologies and Alternative energy solutions: (6 Hrs)
Design for Energy Efficiency, Photochemical Reactions, Advantages of and Challenges Faced by Photochemical, Processes, Examples of Photochemical Reactions, Chemistry Using Microwaves, Microwave Heating, Microwave-assisted Reactions, Sonochemistry, Sonochemistry and Green

Chemistry, Electrochemical Synthesis, Examples of Electrochemical Synthesis. Designing greener processes: Conventional Reactors, Batch Reactors, Continuous Reactors, Inherently Safer Design, Minimization, Simplification, Substitution, Moderation, Limitation, Process Intensification, Some PI Equipment, Examples of Intensified Processes, In-process Monitoring, Near-infrared Spectroscopy

Unit 6: Industrial case studies: (7 Hrs)
A Brighter Shade of Green, Greening of Acetic Acid Manufacture, EPDM Rubbers, Vitamin C, Leather Manufacture, Tanning, Fatliquoring, Dyeing to be Green, Some Manufacturing and Products Improvements, Dye Application, Polyethene, Radical Process, Ziegler–Natta Catalysis, Metallocene Catalysis, Eco-friendly Pesticides, Insecticides. An integrated approach to a greener chemical industry: Society and Sustainability, Barriers and Drivers, The Role of Legislation, EU White Paper on Chemicals Policy, Green Chemical Supply Strategies

Text Books:

1. Mike Lancaster, Green Chemistry, Royal Society of Chemistry, 2010.
2. Paul T. Anastas John C. Warner, Green Chemistry: Theory and Practice, Oxford University Press, 2000.
3. Jay Warmke, Annie Warmke, Green Technology, Educational Technologies Group, 2009.

E-Resources: NPTEL/SWAYAM

BE (Chemical Engineering)-2019 Course

Code: 409345

Elective IV

Credits: 3

409345: (D) Advanced Separation Processes

Teaching Scheme:	**Examination Scheme:**
Lectures : 3 hr / week	In Semester: 30
	End Semesters: 70
	Total: 100

Course Outcomes:

CO1	To built advanced concepts of separation techniques used in chemical industries.
CO2	To investigate the principles and functioning advanced separation techniques.
CO3	To utilize the advanced separation technique in problem solving where conventional techniques are not fruitful and require replacement.
CO4	To Identify the applications of advanced separation techniques as per industrial requirement.
CO5	To recognize the selection criteria between advanced separation techniques and conventional separation techniques
CO6	To Identify the suitable technique for the Separation of specific component in various industrial application.

Unit I: Multicomponent Distillation (6 h)

Multicomponent distillation - basic principles, low key high key components, concept of K value and its application in design, tray to tray calculations, Thiele-Geddes and Maddox methods, case studies, Azeotropic and extractive distillation, choice of entrainer.

Unit II: Azeotropic & Extractive Distillation (7 h)

Azeotropic & extractive distillation – working principles, residue curve maps, homogeneous azeotropic distillation, pressure swing distillation, column sequences, heterogeneous Azeotropic distillation.

Unit III: Reactive Separations (7 h)

Separation based on reversible chemical complexation, reactive distillation, reactive extraction, reactive crystallization, working principles and process design aspects for all, applications of all.

Unit IV: Membrane Separation Techniques (7 h)

Mechanisms of separation in MF,UF,RO, dialysis, electro dialysis, pervaporation, gas permeation and their mass transfer aspects in detail, design parameters for all processes, fouling, liquid emulsion membranes, industrial applications.

Unit V: Adsorption **(6 h)**

General principles, detailed study of temperature swing adsorption (TSA) and pressure swing adsorption (PSA) with study of cycles, liquid chromatography as a separation processes- basic concepts, phenomena and their characterization, chromatography options, separation systems, characteristics of solids and their selection for various applications, column design and filling, applications of chromatography in separation of enzymes and proteins, industrial examples.

Unit VI: Non Conventional Separation Techniques **(7 h)**

Introduction and working principles - zone electrophoresis, zone refining, molecular sieves, ultra centrifugation, foam formation, collapse and drainage phenomena, and equipments, adsorption properties of foams, modes of operation of foam fractionation equipments, principle of froth flotation, properties of foam related to flotation operation, design and development of flotation equipment, applications of the above.

Reference Books:

1) "Basic Principles of Membrane Technology", Mulder M., Luksvar Academic.
2) "Chemical Engineering Vol- 2 ", Richardson – Coulson, Pargamon.
3) "Mass transfer Operations", Treybal, Mc GRaw Hill Publication.
4) "Handbook of Separation Process Technology", Rousseau, Wiley –Interscience.
5) "Separation Techniques for chemical engineers", Schweitzer, Mc Graw – Hill Publications
6) Separation processes, King C. J., Mc GRaw Hill Publication.

BE (Chemical Engineering)-2019 Course
Code: 409347
Computer Aided Chemical Engineering II

Credits: 1

Teaching Scheme:	**Examination Scheme:**
Practical: 2 Hrs/ Week	TW: 50 Marks Total: 50 Marks

Minimum 10 Practical Assignments must be completed using computational as well as simulation softwares. **Aspen plus**, ***Hysys, ChemCAD, EnviroPro, ANSYS, Mathcad, Matlab, Unisim, DWSim etc***. can be used for solving practical assignments.

1. Computer program for solving basic linear algebra involving matrix operations
2. Computer program for solving non-linear algebraic equation/s
3. Computer program for solving steady state staged operation (distillation, gas absorption, L-L extraction, etc.)
4. Computer program for solving un-steady state staged operation (distillation, gas absorption, L-L extraction, etc.)
5. Computer program for plotting P-x-y and T-x-y diagram
6. Computer program for design of reactor/ heat exchangers. distillation column/or any chemical equipment
7. Computer program for solving ODE or PDE using finite difference method
8. Simulation of mass transfer equipment using simple and rigorous methods
9. Simulation of product synthesis using different reactors
10. Simulation of steady state flow sheet synthesis
11. Simulation of dynamic flow sheet synthesis
12. Simulation of fluid flow problems with or without heat/mass transport

BE (Chemical Engineering)-2019 Course
Code: 409348
Project Phase I Credits: 1

Teaching Scheme: | **Examination Scheme:**

Practical: 4 h / week | **TW: 50**
Total: 50

The department should display the list of approved teachers (guides) along with the project titles proposed by them. The students should be given liberty to choose the project area and project guide of their own choice. The student can also choose a state-of-the-art problem of their own interest based on the recent trends in Chemical Engineering / Science in consultation with the guide. They shall work on the designated problem either individually or in groups (maximum **two** students per group).

During the first term the students are required to:

1. Define the research problem.
2. Write a *research proposal*, which should contain –
   a. Project title
   b. Introduction
   c. Origin of the problem
   d. Literature review of research and development at national & international level
   e. Significance of the problem
   f. Objective
   g. Methodology
   h. Details of collaboration (if any)
3. Carry out *preliminary* experimental investigations or product design or process design etc.
4. Summarize the results (if any).

The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student at the mid of the term and should be **submitted along with project report** at the end of respective terms to the examiners as a supporting document for evaluation. Every student will be examined orally based on the topic of his/her project and relevant area to evaluate his understanding of the problem and the progress made by the student during the term. Students should submit a neatly typed and spiral bound *research proposal* at the end of the first term in the following format.

Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc.

Referencing style:

1. Guo J. X. and Gray D. G., Chiroptical behavior of (acetyl)(ethyl)cellulose liquid-crystalline solutions in chloroform, *Macromolecules, 22*, (1989), 2086.

   (Reference numbers should be mentioned in the main text as a superscript)

The proposal should contain:

Page 1: The cover page - should mention: Project title, Name of the student, Name of the guide, Exam seat number and Year.

Page 2: Certificate

Page 3: Index

Page 4 onwards: Research proposal (as above), experimental investigation details and result if any. Last page: References

The department should prepare a template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports.

Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.

Note: The project guides are required to educate the students about antiplagiarism policy of SPPU and apply the same while doing the project.

SEMESTER II

BE (Chemical Engineering)-2019 Course
Code: 409349
Process Modeling & Simulation
Credits: 3 + 1

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

Examination Scheme:
In Semester: 30
End Semesters: 70
Oral: 50 Marks
TW: 25
Total: 175

Course Outcomes:

CO1	Understand different types of models and fundamental laws governing models.
CO2	Apply modeling laws to Fluid flow system& simulation.
CO3	Develop mathematical models for heat transfer systems.
CO4	Formulate modeling equations for mass transfer systems.
CO5	Apply modeling laws to different types of chemical reactors & simulation.
CO6	Simulate mathematical models using various numerical methods.

Unit I: Introduction to Modeling (6 h)

Introduction, definition of modeling and simulation, different types of models, application of mathematical modeling, scope of coverage. Fundamental Laws: Continuity equation, energy equation, and equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics.

Unit II: Models in Fluid Flow Operations: (7 h)

The continuity equation, Flow through Packed bed column, Laminar Flow in narrow Slit, Flow of Film on the outside of circular tube, Momentum fluxes for creeping flow in to slot.

Unit III: Heat Transfer and other Equipments (7 h)

Two heated tanks, double pipe heat exchanger, shell and tube heat exchanger, cooling towers Single effect and multi effect evaporators, agitated vessels, pressure change equipments, mixing process, fluid – solid operations.

Unit IV: Mass Transfer Equipments (7 h)

Flash distillation, differential distillation, and continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying equipments, adsorption, absorbers and strippers. Batch liquid- liquid extraction, continuous extraction, multistage counter current extraction, Mixer-Settler Extraction Cascades, Staged Extraction Columns.

Unit V: Reaction Equipments (7 h)

Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Slurry reactor, Trickle bed reactor, Bubble column reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.

Unit VI: Applications of modeling and simulation (6 h)

Applications of modeling and simulation in distillation, Transient analysis of staged absorbers, unsteady state analysis in reactor system, Modeling and simulation of effluent treatment plant, Use of numerical methods to solve different models.

Practical:

Ten practical will be conducted with the use of mathematical and chemical engineering CAD software's such as ***Hysys,*** **Aspen plus,** ***ChemCAD, EnviroPro, Mathcad, Matlab, Unisim, DWSim*** etc. development

of programs for numerical methods and process simulation.

Reference Books:

1. Luyben W. L., "Process Modeling Simulation and Control for Chemical Engineers", McGraw Hill, 1988.
2. Davis M. E., "Numerical Methods and Modeling for Chemical Engineers", Wiley, New York, 1984.
3. Finlayson B. A., "Nonlinear analysis in Chemical Engineering", McGraw Hill, New York, 1980.
4. Chapra S.C., R.P. Canale, "Numerical Methods for Engineers", Tata-McGraw Hill Publications
5. Franks R.E.G., "Modeling and Simulation in Chemical Engineering", Wiley Intrscience, NY
6. John Ingam, Irving J. Dunn., "Chemical Engineering Dynamic Modeling with PC Simulation", VCH Publishers.
7. Kayode Coker A., "Chemical Process Design, Analysis and Simulation", Gulf Publishing Company.
8. Himmelblau D., K.B. Bischoff, "Process Analysis and Simulation", John wiley & Sons.
9. Wayne Blackwell, "Chemical Process Design on a Programmable Calculator", McGraw Hill.
10. R. W. Gaikwad, "Process Modeling and Simulation", Dennett & Co.

BE (Chemical Engineering)-2019 Course
Code: 409350
Process Engineering Costing & Plant Design
Credits: 3 + 1

Teaching Scheme:	**Examination Scheme:**
Lecture: 3 hrs/week	In Semester: 30
Practical: 2 hrs/week	End Semesters: 70
	Oral: 50
	TW: 25
	Total: 175

Course Outcomes:

CO1	Apply the knowledge of overall aspects of the Chemical Engineering Plant Design.
CO2	Implement basic concepts and various terms of cost Engineering and make cost estimation and cost-profit analysis of chemical manufacturing process.
CO3	Apply Techniques for economic optimization and optimum design.
CO4	Understand the optimization of different process equipment.
CO5	Apply network Techniques such as CPM and PERT for the Chemical Engineering Project management.

Unit I: Process Development (6 h)

Process selection, study of alternative processes, pilot plant, scale up methods, flow sheet preparation, sketching techniques, equipment numbering, stream designation, material and energy balances. Plant Design: Design basis, process selection - selection of equipment, specification and design of equipment’s, material of construction, plant location, plant layout and installation, safety, start up, shutdown and operating guidelines, loss prevention and Hazop study.

Unit II: Cost Engineering (7 h)

Time value of money and equivalence, interest-simple, compound and continuous, present worth and discount, annuities, perpetuities and capitalized cost methods, depreciation, nature of depreciation, methods of determining depreciation, taxes and insurances, types of taxes and insurances, procedure for cost comparison after taxes.

Unit III: Cost Estimation (7 h)

Cash flow for industrial operations, cumulative cash position of cash flow for an industrial operations, capital investments, fixed capital cost, working capital cost, start-up costs, process equipment cost estimation, cost index, cost factors in capital investment, methods of estimating capital investment, estimation of plant cost, estimation of total product cost, manufacturing cost, general expenses. Profitability: Criteria of profitability, payout period, return on investment, present value, cash flow analysis, alternative investment analysis.

Unit IV: Economic Optimization and Optimum Design (7 h)

Nature of optimization, uni-variable and multivariable systems, analytical, graphical and incremental methods of solution, Lagrange multiplier method, linear programming, other techniques and strategies establishing optimum conditions, break even chart for production schedule, optimum production rates in plant operation, optimum conditions in batch and cyclic operation.

Unit V: Optimization of Different Process Equipment (6 h)

Transportation systems, heat exchangers, evaporators, mass transfer equipments and reactors. determination of height and diameter of different process equipments at conditions of optimum cost. Pinch technology analysis. Preparation of techno-economic feasibility report.

Unit VI: Scheduling and Networking of Project (7 h)

Role of project engineering in project organization, start up and shut downs of project; preliminary data for construction projects; process engineering; plot plans, scheduling the project; engineering design and drafting, the design report, organization of design report. Critical path method (CPM): events and activities; network diagramming; earliest start time and earliest finish time ;latest start time and latest finish time; float, advantage of CPM; cost to finish t h e projects earlier than normal cost; precedence diagramming. programme evaluation and review technique (PERT): pert network and time estimates.

Practical:

1. Minimum six drawings of following preferably on Auto CAD/Autodesk.
   Standard symbols as per IS code
   Process flow diagram.
   Piping and instrumentation diagram.
   Utility diagram.
   Plant layouts and elevations.
   Piping GA drawing.
   Piping isometrics.
2. Minimum two assignments based on theory to be solved on computer.

Reference Books:

1. M. S. Peters & K. D. Timmerhaus, "Plant Design and economics for chemical engineers." Mc Graw Hill (2002).
2. Richard Turton, R.C. Bailie, W.B. Whiting, J.A. Shaeiwitz, "Analysis, Synthesis and Design of Chemical Processes", Prentice Hall
3. R.K Sinnot," Coulson & Richardson's Chemical Engineering- Chemical Engineering Design", Vol. 6, Butterworth-Heinemann
4. Kalyanmoy Deb, "Optimization For Engineering Design-Algorithms and Examples", PHI Learning Private Limited
5. S.S. Rao, "Engineering Optimization- Theory and Practice", New Age International
6. T.F.Edgar, D.M. Himmelblau,"Optimization of Chemical Processes", McGraw Hill
7. Srinath L. S., “PERT AND CPM.” affiliated East Press Pvt. Ltd., New York (1973)
8. Perry J. H.,”Chemical engineering handbook” 7TH ed. Mc Graw Hill (1997)

BE (Chemical Engineering)-2019Course

Code: 409351

Elective V

Credits: 3

409351: (A): Energy Audit and Conservation

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit 1: Energy Scenario: **(7 Hrs)**

Classification of energy sources, commercial and noncommercial energy, energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario. energy and environment, air pollution, climate change, energy security, energy conservation and its importance, energy strategy for the future, energy conservation act-2001 and its features. Applications of renewable energy sources.

Unit 2: Energy Management and Audit: (6 Hrs)

Definition, energy audit – need, types of energy audit, energy management (audit) approach understanding energy costs, bench marking, energy performance, matching energy use requirement maximizing system efficiencies, optimizing the input requirements, fuel and energy substitution, energy audit instruments, role, responsibilities and duties of energy management

Unit 3: Guidelines for writing energy audit report: **(7 Hrs)**

Report-writing, preparations and presentations of energy audit reports, Post monitoring of energy conservation projects, MIS, Case-studies / Report studies of Energy Audits, data presentation in report, findings recommendations, impact of renewable energy on energy audit recommendations. Instruments for Audit and Monitoring Energy and Energy Savings, Types and Accuracy. Case studies of implemented energy cost optimization projects in electrical utilities as well as thermal utilities.

Unit 4: Energy Available for Industrial Use: (7 Hrs)

Introduction, methodology for forecasting industrial energy supply and demand. New energy technologies and conservation, motivation of implementing conservation measures, evaluating costs and benefits of conservation measures.

Unit 5: Management and Organization of Energy Conservation Programs: (6 Hrs)

Human aspect of energy conservation, involvement tree, elements of energy management program, promoting energy conservation, program planning, setting goals, setting priorities, allocation of resources, and scheduling, measuring, monitoring and reporting, organization of energy conservation programs, plant level organization, division level organization, corporate level organization.

Unit 6: Guidelines for Improving Process Operations for Energy Conservation: (7 Hrs)

Energy conservation checklist, potential energy conservation in boilers, chilled water plants and central air –conditioning system, compressors and fans, heat pumps and cooling systems, water heaters and coolers, lighting systems, motors and transformers, mixing vessels, heat exchangers, evaporators, distillations, housekeeping

Textbooks:

1. Industrial Energy Management and Utilization, Larry C. Witte, Philip S. Schmidt, Davis R. Brown. 1988
2. Energy Engineering and Management- Amlan Chakrabarti, PHI Learning-2011.
3. Energy Conservation in the Chemical and Process Industries, Colin D. Grant, The Institution of Chemical Engineers. 1979

References Books:

1. Handbook of Industrial Energy Conservation, S. David HU.
2. Guidebook for National Certification Examination for Energy Managers and Energy Auditors- Book 1, 2,3 and 4. Bureau of Energy Efficiency (BEE)
3. Energy Conservation in the Process Industries- W. F. Kenny, Academic Press Inc., 1984
4. Solar Engineering of Thermal Processes, John A. Duffie and William A. Beckman, 3rd edition-2006

E-Resources: NPTEL/SWAYAM Courses

BE (Chemical Engineering)-2019 Course
Code: 409351
Elective V
Credits: 3

409351: (B) Chemical Process Safety

Teaching Scheme:
Lectures: 3 h / week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Course Outcomes:

CO1: Able to estimate incident rates and toxicity level in process industries

CO2: Able to evaluate the work space environment related to noise, dust and toxicants

CO3: Able to study fire and explosion in Chemical and Allied industries

CO4: Able to understand the methods to prevent fire and explosion

CO5: Able to conduct HAZOP studies in chemical industries

CO6: Able to implement various techniques for safe work environment

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Unit I: **(6 h)**

Concepts and definition, safety culture, storage of dangerous materials, plant layout safety systems, OSHA incidence rate, FAR, FR, The accident process: Initiation, propagation, and termination, toxicology: ingestion, inhalation, injection, dermal absorption, dose versus response curves, relative toxicity, threshold limit values.

Unit II: **(7 h)**

Industrial hygiene: government regulations, identification, evaluation: evaluating exposures to volatile toxicants by monitoring, evaluating worker exposures to dusts, evaluating worker exposures to noise, estimating worker exposures to toxic vapors.

Unit III: **(7 h)**

Technology and process selection, scale of disaster, fire triangle, distinction between fires and explosion, definitions of ignition, auto-ignition temperature, fire point, flammability limits, mechanical explosion deflagration and detonation, confined explosion, unconfined explosion, vapour cloud explosions, boiling liquid expanding vapour explosion (BLEVE), dust explosion, shock wave, flammability characteristics of liquids and vapours, minimum oxygen concentration (MOC) and inerting.

Unit IV: **(7 h)**

Control of toxic chemicals, Storage and handling of flammable and toxic chemical, Runway reactions, Relief system risk and hazards management, Design to prevent Fires and Explosions: Inerting, static Electricity, Explosion proof equipment and Instrument, Ventilation, sprinkler systems and Miscellaneous Design for preventing Fires and Explosion.

Unit V: **(6h)**

Hazards identification: process hazards checklists, hazard surveys, hazard and operability studies (HAZOP), safety reviews. Risk assessment: review of probability theory, interaction between process units, revealed and unrevealed failure, and probability of coincidence, event trees and fault trees.

Unit VI: **(7h)**

Safety versus production, Hazard models and risk data. Tackling disasters, plan for emergency. Risk management routines, Emergency shutdown systems, Role of computers in safety, Prevention of hazard human element, Technology and process selection.

References:

1. Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with applications, Prentice Hall, Inc, 1990.
2. P. P. Leos, Loss prevention in process Industries, Vol 1 and 2 Butterworth, 1983
3. R. W. King and J. Magid, Industrial Hazards and Safety Handbook, Butterworth, 1982
4. Khulman, Introduction of Safety Science, TUV Rheinland, 1986
5. W. E. Baker, Explosion, hazards and Evaluation, Elsevier, Amsterdam, 1983
6. O. P. Kharbanda and E. A. Stallworthy, Management of Disasters and How to Prevent Them. Grower 1986

BE (Chemical Engineering)-2019 Course

Code: 409351

Elective V

Credits: 3

409351: (C) Computational Fluid Dynamics

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit I: Governing Equations (7 h)

Fluid flow phenomena, flow terminologies, conservation principles, Reynolds Transport Theorem, Stokes Theorem, Integral and Differential approaches, Equation of continuity, Navier stokes equations, Energy Equation, equations in vector forms, Mathematical classification of governing equations, Boundary conditions, conservative and non-conservative forms.

Unit II: Solution Techniques for Governing Equations: FDM (7h)

Discretization of governing equations using FDM, FDM grid, forward differencing, backward differencing, FTCS, Explicit methods, Implicit Methods, Semi-implicit methods, solving of governing equations using Euler's, Jacobi, Crank Nicholson and ADI Methods, error analysis, stability criterion, Courant-Friedrichs-Levi condition, convergence and consistency

Unit III: Solution Techniques for Governing Equations: FVM (7h)

Finite volume concept, FVM mesh, discretization using FVM, solution of 1-D diffusion equation with and without sources, solution of 2-D diffusion steady and unsteady state, solution of convection-diffusion equation, Conservation, Accuracy, Convergence, Consistency, Stability, Transportive-ness, boundedness, upwind schemes, pressure-velocity coupling, SIMPLE, SIMPLEC and SIMPLER algorithms.

Unit IV: CFD modeling of Turbulence Flows (7h)

Introduction to turbulent flows, characteristics, time averaging techniques, mean velocity, turbulent eddies and scales, RANS, Reynolds stresses, turbulent flow models, mixing length, energy dissipation, algebraic models, one equation models, Spalart-Allmaras Model, two equation models, **k-** ε and k- ω models, problem closure, Direct Numerical Solution, Large Eddy Simulation,

Unit V:CFD modeling of Multiphase Flows (6h)

Basic Physics of Multiphase flow, applications, classification of multiphase flows, flow patterns, dispersed phases, separated phases, bubbly, slug, annular, stratified, wavy flows for horizontal and vertical geometries, governing equations, Multiphase flow modeling, discrete phase modeling, continuous phase modeling, VOF, Euler-Euler, Euler-Lagrangean Models.

Unit VI: CFD Simulation **(6 h)**

Applications and Scope of CFD, advantages and limitations, stages of CFD simulations, introduction to CFD Software (Ansys/Open Foam),preprocessing, grid types, geometry and mesh generation, solvers, different models for CFD simulation, boundary conditions, post processing, graphics and animations, plots, contours, streamlines, velocity profiles

Reference Books:

1) Anderson J. D. 1992.Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill
2) Ferziger J. H. 2002. Computational Methods for Fluid Dynamics,3rd Edition, springer
3) Patankar S.V. 1981.Numerical Heat Transfer and Fluid Flow, McGraw-Hill
4) Moukalled F., Mangani L.,Darwish M.2015.The Finite Volume Method in Computational Fluid Dynamics: An Advanced Introduction with OpenFOAM® and Matlab, springer
5) Brennen C. E.2005. Fundamentals of Multiphase Flows, Cambridge University Press
6) Versteeg H. K., Malalasekera W. 1995. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson

BE (Chemical Engineering)-2015 Course
Code: 409351
Elective V
Credits: 3

409351: (D) Advanced Materials

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit I: (6h)

Advanced metallic systems, steels for special applications, austempered ductile iron.

Unit II: (7h)

Advanced polymeric materials, new polymeric materials such as Kevlar, Nomex, UHMWPE and fiber technology.

Unit III: (7h)

Advanced ceramic materials, advanced powder synthesis techniques, advanced processing methods, micro structural design and grain boundary engineering, case studies.

Unit IV: (7h)

Introduction to composite materials, factors influencing the properties of composite materials like fiber parameter, matrix, interface & molding methods. Phase selection criteria. reinforcing mechanisms. interfaces, advantages and disadvantages. Polymer composites. Reinforcing and matrix materials, prepregs, fiber winding techniques, fabrication techniques, laminates, mechanical behavior, etc

Unit V: (6h)

Metal composites, types of reinforcement, chemical compatibility, fabrication processes, mechanical behaviour and properties, ceramic composites. Matrices and reinforcement. Why to reinforce ceramics, fabrication methods, crack propagation and mechanical behaviour.

Unit VI: (7h)

Carbon composites, their properties, fabrication methods and their applications, ablative polymers, their applications, air craft materials, introduction to nonmaterial, synthesis & characterization of nonmaterial, application of nonmaterial with special reference to chemical engineering.

Reference Books:

1. Modern Ceramic Engineering, Richorson R.W., Marcel Dekker.
2. Composite Materials, Chawala K.K., Springer Science & Business Media.
3. FRP Technology, Weather head R., Applied Science Publishers.
4. Engineering Polymers, Dyson R.W., Springer Science & Business Media
5. Polymers of high technology, electronics and photonics, Bowden M.J & Turner S.R., ACS Symp. Ser. 346, 1987.

BE (Chemical Engineering)-2019 Course
Code: 409352
Elective VI
Credits: 3
409352: (A) Catalysis

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit I: **(6h)**

Introduction to catalysis, application to industrial processes – one example each from inorganic, fine organic chemical, petroleum refining, petrochemical and biochemical industries. Types of catalysis: homogeneous catalysis.

Unit II: (7h)

Heterogeneous catalysis: introduction, phase transfer and tri-phase catalysis, liquid – liquid and solid – liquid catalysis, mechanism, engineering problems, mass transfer considerations and reactor types.

Unit III: **(7h)**

Gas – solid catalytic reactions: adsorption theories and concept of active site. Adsorption isotherm and Langmuir – Hinshelwood approach, diffusion effects in the catalyst.

Unit IV: (7h)

Preparation of catalysts – supported metal and metal oxide catalyst. major steps involved in catalysts preparation and formation, physical methods of catalyst characterization for determination of surface area by bet method, pore volume and average pore size distribution, effectiveness of the catalyst, selectivity of the catalyst, deactivation of catalyst, mechanism of catalyst poisoning.

Unit V: (6h)

Zeolites – structural chemistry of Zeolites, templated molecular sieves, size and shape selectivity, a few industrial applications of Zeolites, modification of Zeolites.

Unit VI: (7h)

Biocatalysts – enzymes, lipases and microbes as catalysts, mechanism of participation of enzymes in a few typical reactions, Michaelis – Menten kinetics, inhibition of enzyme reaction and kinetics.

Reference Books:

1. Smith J.M.: “Chemical Engineering Kinetics”, 3rd Edition, McGraw Hill
2. Satterfield Charles N.: Heterogeneous Catalysis in Industrial Practices, McGraw- Hill International Editions, 2nd Edition 1993.
3. Bailey James, Davis Ollis: “Biochemical Engineering”, McGraw Hill
4. Wingard L.B.: Enzyme Engineering, Fr. Inter Science, N.Y. 1972.
5. Carberry J. J.: Chemical and Catalytic Reaction Engineering, McGraw Hill, New York, 1976.

BE (Chemical Engineering)-2019 Course
Code: 409352
Elective VI
Credits: 3

409352: (B) Nanotechnology

Teaching Scheme:
Lectures: 3 h / week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Course Outcomes:

CO1	To understand the concept of Nano scale and Nanotechnology, and classify various types of Nano material.
CO2	Learn the synthesis procedure of Nano material and its method of synthesis according to application.
CO3	Identify the suitable type of Characterization technique for Nano material.
CO4	distinguished the fundamental concept of Nano colloids and its chemistry and learn about aspects of quantum dots
CO5	Identify the concept of semiconductor and its types and differentiate between intrinsic and extrinsic semiconductors and P-n junction.
CO6	Identify the application of Nanotechnology in chemical Engineering and evaluate the impact of Nanotechnology on Environment and its safety aspects.

Unit I: Introduction (6h)

Introduction to nanotechnology and nanomaterials, how it all began: synthesis of carbon buck balls, list of stable carbon allotropes extended, fullerenes, metallofullerenes, solid C60, bucky onions, nanotubes, nanocones, properties of individual nanoparticles, methods of synthesis for carbon nanostructures

Unit II: Synthesis Procedures of Nanomaterials (7h)

Bottom-up vs. top-down, epitaxial growth, self-assembly, modelling and applications production techniques of nano-tubes carbon arc bulk synthesis in presence and absence of catalysts high-purity material (bucky paper) production using pulsed laser vaporization (PLV) of pure and doped graphite high-pressure CO conversion (HIPCO) nano-tube synthesis based on boudoir reaction chemical vapor deposition (CVD)

Unit III: Characterizations of Nanomaterials (7h)

Optical microscopy, electron microscopy, secondary electron scattering, back scattering, scanning probe microscopes, focussed ion beam technique, X-ray diffraction, SPM-AFM, STM, optical, electronic and vibrational spectroscopic tools.

Unit IV: Semiconductors and Quantum Dots (7h)

Intrinsic semiconductors, band gaps, law of mass action, mobility of charge carriers extrinsic semiconductors the p-n junction, ferromagnetism energy gaps the nearly free electron model the number of orbitals in a band electrons and holes, effective masses review of classical mechanics, de Broglie's hypothesis, Heisenberg uncertainty principle Pauli exclusion principle, Schrödinger's equation, properties of the wave function, application: quantum well, wire, dot, quantum cryptography

Unit V: Nano Colloids and Chemistry (6h)

Surface tension and interfacial tension surfaces at equilibrium surface tension measurement, contact angles, colloidal stability, electrical phenomena at interfaces Van der Waals forces between colloidal particles, Photocatalysis nanostructured materials. Self-assembly and catalysis.

Unit VI: Unit Applications, Safety and Environment (7h)

Waste water treatment, nanobiotechnology: drug delivery, nanoclay, nanocomposites, surface coatings. self cleaning materials, hydrophobic nanoparticles. biological nanomaterials. Nanoelectronics,. nanomachines & nanodevices societal, health and environmental impacts.

Commercial processes for nanotechnology and chemical engineering applications: nanohydrogel, photocatalytic reactors, nanoclay synthesis, polymer nanocomposite, introduction to industries which produces commercial nanomaterials

Reference Books:

1. Introduction to Nano Science, (CRC Press of Taylor and Francis Group LLC), G. Louis Hornyak, Joydeep Dutta, Harry F. Tibbals and Anil K. Rao, May 2008, 856pp, ISBN-13: 978142004805
2. Ashby, Michael F., Ferreira, *Paulo* J., Schodek, Daniel L. 2009. *Nanomaterials and nanotechnologies*: An overview. In: Nanomaterials, Nanotechnologies and Design, Linacre Haus, Jordan Hill, Oxford, 2009.
3. Introduction to Nanoscience and Nanotechnology, K. K. Chattopadhyay, A.N. Banerjee, PHI Learning Private Limited.
4. Applied Colloid and Surface Chemistry, Richard M. Pashley and Marilyn E. Karaman, John Wiley & Sons Ltd, 2004.
5. Nanostructuring Operations in Nanoscale Science and Engineering, Kal Renganathan Sharma, The McGraw-Hill Companies, Inc. ISBN: 978-0-07-162609-5, 2010.

BE (Chemical Engineering)-2019 Course

Code: 409352

Elective V

Credits: 3

409352: (C) Fuel Cell Technology

Teaching Scheme:	**Examination Scheme:**
Lectures: 3 h / week	In Semester: 30
	End Semester: 70
	Total: 100

Unit I: Fundamentals (6 h)

Electrochemical cells, electrolytic cell, galvanic cell, construction and working, Faraday's law of electrolysis, problems on displacements, classification of electrodes, Nernst's theory, single electrode potential , EMF of cell, EMF series, common types of cells.

Unit II: Introduction (7 h)

Potential convention, current conventions, equilibrium constants, mass transfer limited current, Cottrell equation, factors affecting reaction rate and current, mechanism involving electrode reactions, reversibility kinetics, Butler-Volmer Equations, Tafel plots , Tafel equation, equations governing modes of mass transfer – Nernst-Planck Equation, Ficks law of diffusion, concept of Helmholtz plane.

Unit III: Hydrogen fuel cell (7 h)

Introduction to hydrocarbon based fuel cells, general issues, fossil fuels and other fuels used, H_2 production from renewable sources and storage, working of H_2 fuel cell, safety issues, steam reforming, internal reforming, cost estimation.

Unit IV: Proton Exchange Membrane Fuel Cell (6 h)

Introduction, working of PEMFC, electro chemistry modeling, exchange current density, local surface over potential (activation loss), current & mass conversion, gas phase species diffusivity, membrane phase electronic conductivity, osmotic drag coefficient, back diffusion flux, fuel crossover.

Unit V: Solid Oxide Fuel Cells (7 h)

Introduction, working of SOFC, modeling SOFC (Nernst voltage, current distribution, & over potential of electrolytes, electric potential field) modeling current transport & potential field, activation over potential, cell potential, treatment of electrolyte interface, Ohmic over potential, Activation over potential, Modeling electrochemical potential.

Unit V: Fuel Cell Systems (7 h)

System processes – fuel processing, rejected heat utilization, system optimization – pressurization, temperature utilization, heat recovery, fuel cell networking, life cycle analysis of fuel cells, hybrid systems – introduction to microbial and enzymatic fuel cell.

Reference Books:

1. Bokris John O’m, Srinivasan S., “Fuel cells-their electrochemistry”, McGraw Hill 1969.
2. Appleby A.J. Fralkes F. R., “Fuel cell handbook”, Van Nostrand Reinhold 1989.
3. Kordesch Karl, Simader G., “Fuel cells and their applications”, VCH publications 1996.
4. U S Department of energy, “Fuel cell: a handbook”,
5. Leo J.M.J., Blomen, Mugerwa M. N., “Fuel cell systems”, Plenum Press.

BE (Chemical Engineering)-2019 Course
Code: 409352
Elective VI
Credits: 3

409352: (D) Petrochemical Engineering

Teaching Scheme:
Lectures: 3 h / week

Examination Scheme:
In Semester: 30
End Semester: 70
Total: 100

Course Outcomes:

CO1	Analyze status of petrochemical industries and its necessity in India
CO2	Get acquainted and interpret the first generation petrochemicals and its basic raw materials
CO3	Evaluate and recognize process and methodology for separation and purification techniques in petrochemical complexes
CO4	Analyze and Differentiate between First generation and second generation petrochemicals and its feedstock and different types of polymers and its preparation methodologies along with its use in industries.
CO5	Evaluate the different safety norms and aspects in petrochemical industry and pollution control norms and methods of elimination.

Unit I: **(6h)**

Introduction to petrochemical, petrochemical industry in India, basic raw material for petrochemical synthesis and their sources, preparation of feedstock for petrochemical production, main building blocks of petrochemical industry

Unit II: **(7h)**
First generation raw material like olefins, aromatics, naphthenes. Production of aromatics, naphthenes and other hydrocarbon feedstock, aromatic separation into B, T, X.

Unit III: **(7h)**
Production of low molecular weight olefins by hydrocarbon cracking, furnaces, separation techniques and purification.

Unit IV: **(7h)**
Combining olefins and aromatics to produce second generation intermediates such as glycols, amines, acids, ketones that can be used also as solvents and formulating agents.

Unit V: **(7h)**
Polymers: bulk, engineering and specialty, types of polymerization such as bulk, emulsion and suspension etc, at least two polymeric products and manufacture from each class, few examples (flow sheet, applications) of polymers like polyester, nylon, etc

Unit VI: **(6h)**

Integration of refinery and petrochemical plants with power generation, pollution control – norms and methods of elimination, brief description on safety considerations

Reference Books:

1. Modern Petroleum Technology, Hobson and Pohl, Vol. I & II, John Wiley and Sons, New York.
2. Introduction to petrochemical industry and refinery by Speight, Encyclopedia of Life Support systems.
3. Dryden’s Outline of chemical industry, M Gopal Rao, M Sittig, East –West press.
4. Petrochemical Process Technology, ID Mall, Macmillan India Ltd., New Delhi
5. Modern Pertoleum Refinery Engineering, Bhaskar Rao, published by Aman Dhanani.

BE (Chemical Engineering)-2019 Course
Code: 409353
Phase II
Credits: 6

Teaching Scheme:
Practical: 12 h / week

Examination Scheme:
TW: 100
OR: 50
Total: 150

During the second term the students are required to:

1. Carry out detailed experimental work on previously defined (Phase I) research problem.
2. Write a *Project Report,* which should be broadly divided into the following sections –
    a. Abstract
    b. Introduction
    c. Experimental
    d. Results and Discussion
    e. Conclusion
    f. Plant layout and costing
    g. References

Students should submit a neatly typed and spiral bound *Project Report* at the end of the term in the following format.

Font: Times New Roman, Font size: 12, Headings: 14, Spacing: 1.5, typed on one side of the A4 size paper with proportionate diagrams, figures, graphs, photographs, tables etc.

Referencing style:

2. Guo J. X. and Gray D. G., Chiroptical behavior of (acetyl) (ethyl) cellulose liquid-crystalline solutions in chloroform, *Macromolecules*, *22*, (1989), 2086.

(Reference numbers should be mentioned in the main text as a

superscript) The *Project Report* should contain:

1. The cover page –must mention: Project title, Name of the student(s), Name of the guide, Exam seat number and Year.
2. Certificate from guide
3. Certificate from industry (if any)
4. Index
5. Detailed *Project Report* having sections 'a' to 'g' from above.

The student is required to prepare a month wise work plan (for both semesters) immediately after the allotment of the project and the department is required to maintain a progress report of every student/project. The progress report should reflect monthly progress done by the student as per the work plan. The progress report is to be duly signed by the respective project guide by giving the remarks/marks/grades etc. on the periodic progress done by the student at the mid of the term and should be **submitted along with project report** at the end of respective terms to the examiners as a supporting document for evaluation.

Each student is required give **presentation** of his work for 10 minutes using 10-12 slides. The presentation will be followed by question answer session of 5 min. Every student will be examined orally for 50 marks based on the topic of his/her project and relevant area to evaluate his understanding of the problem. Term work assessment for 100 marks will be based on student's workup, performance and progress (depth and quality of work) during the term.

The department should prepare a template of the format of the project report and supply it to the students so as to maintain the uniformity in the project reports.

Students are encouraged to participate and present their project work in various events, competitions, conferences and seminars etc. in consultation with their guide.

Note: The project guides are required to educate the students about antiplagiarism policy of SPPU and apply the same while doing the project.