Department of Chemical Engineering

Revised Syllabus

Of

Third Year

Chemical Engineering

Shri Guru Gobind Singhji Institute of Engineering &Technology,Vishnupuri-Nanded

Year-2020-21

Shri Guru Gobind Singhji Institute of Engineering &Technology,Vishnupuri-Nanded

(An Autonomous Institute of Government of Maharashtra)

Department of Chemical Engineering

Vision of the Department

To provide world class education and enable the students to provide engineering solutions for industry and society in the field of Chemical Engineering

Mission of the Department

1. To impart formal education in Chemical Engineering and allied areas at under graduate level by integrating a variety of project experiences at every level of the curriculum.

2. Students will be able to apply the knowledge of Chemical Engineering confidently for future applications in the science and technology.

3. To work in network and develop a rapport with world class R&D organizations, educational institutions and industries in India

4. To encourage students for research and development activities, entrepreneurship and start-ups

5. To impart sufficient analytical, logical and managerial skills so that the graduates will be able work comfortably in today's ever-demanding and multi-disciplinary environment

SGGS INSTITUTE OF ENGINEERING & TECHNOLOGY, NANDED

(An Autonomous Institute of Government of Maharashtra)

T.Y. B.Tech. (Chemical Engineering)

Curriculum Structure: Academic Year: 2020-2021 onwards

1) Program Education Objectives (PEOs):

1. A fundamental understanding of the basic and engineering sciences and develop computational and analytical skills required for Chemical Engineering.
2. This program will enable students to provide engineering designs that are based on sound principles considering functionality, aesthetics, safety, cost effectiveness and sustainability.
3. Graduates will be competent enough for higher studies, entrepreneurship/start-ups and administrative services in India as well as abroad.
4. To inculcate in the students professional and managerial skills, communication skills and the life-long learning attitude.

2) Program Outcomes (POs):

Engineering Graduates will be able to:

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and Engineering sciences.
3. **Design/Development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend write effective reports and design documentation, make effective presentations, and give and receive clear instructions and.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

3) Table of Correlation of PEOs and POs as below:

(Correlation Matrix (Correlation between the PEOs and the POs)

PO/PSO ➡ ⬇ PEO	1	2	3	4	5	6	7	8	9	10	11	12
PEO-1	✓	✓			✓							
PEO2			✓			✓	✓				✓	
PEO3				✓					✓		✓	✓
PEO4								✓		✓		✓

4) Structure of curriculum:

Semester V								
S.N.	Course Code along with category	Course Title	Hours per week			Credits		Total
			L	T	P	Th	Pr	
1	PCC-CH301	Mass Transfer-II	03	-	02	03	01	04
2	PCC-CH302	Chemical Reaction Engineering-I	03	-	02	03	01	04
3	PCC-CH303	Process Equipment Design & Drawing	03	-	-	03	-	03
4	PCC-CH304	Numerical Methods in Chemical Engineering	02	-	02	02	01	03
5	PEC-CH3**	Core Elective-I	03	-	-	03	-	03
6	OEC-CH3**	Open Elective-I	03	-	-	03	-	03
7	SII-CH312	In plant Training*	-	-	-	-	-	-
		Total	17		06	17	03	**20**

Note *Students will do in plant training during winter vacation (Sem-I of T.Y.) and evaluation will carried out at the end of semester-II of T.Y.

Core Elective-I List:	**Open Elective-I:**
1. PEC-CH305: Strength of Materials 2. PEC-CH306:Plant Utility 3. PEC-CH307: Material Science and Engineering 4. PEC-CH308: Advance Fermentation Technology	1. OEC-CH309:Instrumentation and Analytical Techniques 2. OEC-CH310: Air Pollution And Control 3. OEC-CH311: Corrosion Engineering

Semester VI								
S.N	Course Code	Course Title	Hours per week			Credits		Total
			L	T	P	Th	Pr	
1	PCC-CH321	Process Dynamics and Control	03	-	02	03	01	04
2	PCC-CH322	Chemical Reaction Engineering-II	03	-	02	03	01	04
3	PCC-CH323	Plant Design & Economics Management	03	-	-	03	-	03
4	PCC-CH324	Chemical Process Industries	03	-	-	03	-	03
5	PEC-CH3**	Core Elective-II	03	-	-	03	-	03
6	OEC-CH3**	Open Elective-II	03	-	-	03	-	03
7	SII-CH312	In plant training	-	-	02		01	01
		Total	18		06	15	03	**21**

Core Elective-II List:	Open Elective-II:
1. PEC-CH325: Polymer Technology 2. PEC-CH326: Advance separation Technology 3. PEC-CH327: Membrane Technology 4. PEC-CH328: Fuel Cell Engineering	1. OEC-CH329: Project Planning & Management 2. OEC-CH330: Renewable Energy Sources 3. OEC-CH331: Solid waste Management

5) Syllabus of course: **Semester V**

i) Title of course:	Mass Transfer-II (PCC-CH301, Credit-04) **(L-03, T-0,P-02)**
ii) Course Outcomes:	1. Ability to estimate pressure drop, bubble size, TDH, voidage, heat and mass transfer rates for gas absorber.
	2. Ability to scale up mass transfer processes for drying.
	3. Calculate energy balance, yield of crystals and quantity of mother liquor in crystallizer.
	4. Use of concept of various mass transfer operations with real life application
	5. Able to do separation by adsorption and design of chromatographic separation equipment's.
iii) Course objectives:	1. To study the fundamentals of various separation techniques related to mass transfer operations.
	2. Teach students how to identify, formulate, and solve engineering problems involving gas absorption, drying, Crystallization, Humidification and dehumidification etc.
	3. Teach students basic of advance separation techniques such as membrane separation, desalination technology, dialysis technique.
	4. To understand the fundamentals about mass transfer coefficients and to solve the examples related to mass transferring devices.
	5. To understand the importance of various mass transfer operations equipment's such as dryer, absorption tower, crystallizer, cooling towers etc. in process industries.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	2	3	2	2	-	1	-	-	-	-	-	1
CO2	3	3	3	2	1	-	-	-	-	-	-	1
CO3	2	3	3	2	1	-	-	-	-	-	-	1
CO4	2	2	3	2	1	2	2	2	-	-	-	1
CO5	2	1	3	2	-	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	**Gas Absorption:** 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, calculation 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, numericals.
Unit -II	**Drying:** 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, numericals
Unit -III	**Introduction to Membranes Separation technology**: Reverse osmosis, ultra-filtration, evaporation, micro filtration, design principles, permeability, desalination technology, dialysis technique, membranes selection and parameters to be considered in design of membranes separation technology
Unit -IV	**Crystallization**: Theory of Crystallization, saturation, super saturation, nucleation and crystal growth, various equipments for crystallization, their operational and design characteristics, calculation of yield, enthalpy balances, equipment
Unit -V	**Humidification and dehumidification**: Equipment's operational characteristics, design procedures and selection criteria along with mass transfer calculations, Types of cooling towers, cooling tower operational characteristics, numerical.

Text book:

Treybal R.E.; Mass Transfer Operations, Edition 3rd, McGraw Hill Book Co., New York

Reference books:

1. Arora,Heat Transfer and Mass Transfer, Khanna Publishers, New Delhi.
2. Badger W.L., Banchero J.T.; Introduction to Chemical Engineering,McGraw Hill Book Co., New York.
3. Brown G.G.; Unit Operations, John Wiley & Sons, New York.
4. Chattopadhyay P., Unit Operations in Chemical Engineering Vol-I &II,Khanna publishers, New Delhi .
5. Coulson J.M., Richardson J.F.; Chemical Engineering Vol.II, edition 3rd, Perganon Press, New York (1987).
6. Lyderson A.L.: Mass Transfer In Engineering Practice, John Wiley & Sons. .
7. McCabe W.L., Smith J.M.&Harriot P.; Unit Operations in Chemical Engineering, 5th Edition, McGraw Hill Book Co., New York, 1993.

Lab work:

1. Natural draft tray dryer: To study the drying Characteristics of a solid material under batch drying conditions.
2. Determination of drying rate and to plot moisture lost with time under for different operating conditions.
3. Forced draft tray dryer: To correlate the constant drying rate with air mass velocity.
4. Spray Dryer – To study the design and Operating Principles of Spray Dryer
5. Rotary Dryer – To study the Characteristics of Rotary Dryer.

6. Batch Crystallizer: To study the performance of a batch crystallizer. To determine the crystal yield and efficiency of crystallizer.
7. Swenson Walker Crystallizer: To determine the crystal yield and efficiency of crystallizer.
8. To study the performance evaluation of fluid bed dryer.
9. To study the characteristics Cooling Tower experiment. To determine rate of evaporative cooling.
10. Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower
11. Absorption in sieve plate column: To study, absorption of CO_2 in aq.NaOH solution in sieve plate column. To determine the gas phase mass transfer coefficient.
12. Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction.

Note: **Total Experiments to be conducted/designed: 8**

i) Title of course:	Chemical Reaction Engineering-I (PCC-CH302, Credit-04) **(L-03, T-0,P-02)**
ii) Course Outcomes:	1. To get the knowledge about the basic concepts of reaction kinetics, rate and order of reactions.
	2. Able to calculate material, energy and behaviour of the reaction balance for reactors.
	3. Able to develop and apply performance equations for batch and continuous reactors.
	4. Able to perform arrangement of reactors and accordingly evaluate the performance of reactors (sizing and volume).
	5. Develop skill to choose the right reactor among single, multiple, recycle etc. schemes and able to understand recycling process and the effect of selectivity and the yield of reactions.
iii) Course objectives:	Students will learn about
	1. The fundamental concepts of Reaction Engineering and type of reactions.
	2. To understand and solve various numerical related to the reaction kinetics and engineering.
	3. Enhance their knowledge on types of reactors, working of reactors, different types of arrangements of reactors to optimise the conversion and economics.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	1	1	-	-	-	-	-	-	1
CO2	2	3	3	2	1	-	-	-	-	-	-	1
CO3	2	2	3	2	1	-	-	-	-	-	-	1
CO4	2	2	3	2	1	-	-	-	-	-	-	1
CO5	3	2	3	2	-	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	**Introduction to Chemical Reaction Engineering:** Classification of reaction based on various terms, Reaction rate, Chemical kinetics, Variables affecting rate of reaction, Speed of reactions, Problems.
Unit -II	**Kinetics of Homogeneous Reactions:** Concentration dependent term and temperature dependent terms of rate equation, Single and multiple reactions, Elementary and non-elementary reactions, Molecularity and order of reaction, Rate constant, Representation of reaction rate, Kinetic models, , searching mechanism, rate controlling step. Temperature dependency from Arrhenius' law, thermodynamics, various theories, Activation energy, Problems
Unit -III	**Interpretation of Batch Reactor Data:** Constant volume batch reactor, Variable volume batch reactor, Integral method and differential method of analysis of kinetic data, other methods of analysis of kinetic data, Temperature and reaction rate, Problems
Unit -IV	**Introduction to Reactor Design:** Types of reactors, PFR, CSTR etc., Material & energy balances single ideal reactor, Space-time and space-velocity, holding time, Introduction of non-ideal flow, Problems. Ideal Reactors for a Single Reaction, Ideal Batch Reactor, Steady State Mixed Flow Reactor, Steady State Plug Flow Reactor, Isothermal Reactors for single Reactions Problems, Design for Single Reactions, Size comparison of single reactors, General graphical comparison, Multiple reactor system, Recycle reactor, Autocatalytic reactions, Problems.
Unit -V	**Design for Parallel Reactions & Series:** Introduction to design of parallel reactions, Qualitative and Quantitative discussion on product distribution, Contacting patterns, Reactor Size and arrangement, Selectivity, Yield, reactors in series, reactors of different types in series, reactors of different types in series, Problems, qualitative and quantitative discussion for multiple reactions, instantaneous and overall fractional yield, problems.
Unit -VI	**Temperature and Pressure Effects:** Single and multiple reactions, Heats of reaction from thermodynamics, Equilibrium constant, Temperature, Graphical design procedure, Optimum Temperature Progression, Heat Effects, Adiabatic and non-adiabatic operations, Problems

Text books:

Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Easter Ltd., New York,1999

Reference:

1. J.M. Smith, "Chemical Engineering Kinetics", 3rd Edn., McGraw Hill, New York, 1981.
2. Arora, Heat Transfer and Mass Transfer, Khanna Publishers, New Delhi. .
3. Badger W.L., Banchero J.T.; Introduction to Chemical Engineering, McGraw Hill Book Co.New York. .
4. Brown G.G.; Unit Operations, John Wiley & Sons, New York.
5. Chattopadhyay P., Unit Operations in Chemical Engineering Vol-I &II,Khanna publishers, New Delhi.
6. Coulson J.M., Richardson J.F.; Chemical Engineering Vol.II, edition 3rd, Perganon Press, New York (1987).
7. Lyderson A.L.: Mass Transfer In Engineering Practice, John Wiley & Sons.
8. McCabe W.L., Smith J.M.&Harriot P.; Unit Operations in Chemical Engineering, 5th Edition, McGraw Hill Book Co., New York, 1993.

Lab work:

Lab work: Perform any eight practical's

1. Study of First order reaction.
2. Inversion of Sucrose.
3. Study of pseudo first order reaction. Acid catalysed hydrolysis of methyl acetate .
4. To determine reaction rate constant and Saponification reaction study in plug flow reactor.(Straight tube)
5. Saponification reaction study in packed bed reactor. To determine reaction rate constant.
6. CSTR: To study the progress of suitable chemical reaction. To determine reaction rate constant. To study the efficiency of mixing.
7. Batch Reactor: To study the progress of suitable chemical reaction and kinetic parameters. To determine the effect of Temperature on reaction rate constant.
8. Continuous Stirred Tank Reactor.
9. Plug flow tubular reactor (Helical coil): To determine reaction rate constant.
10. Study of different types reactors in series. To determine reaction rate constant.
    Study of Isothermal batch reactor.

i) Title of course:	Process Equipment Design & Drawing (PCC-CH303, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Understand the principles and theories combined with a practical knowledge of the limits imposed by environmental, safety and health concerns to design of new process and expansion and revision of the existing process.
	2. Understand the various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of temperature and pressure.
	3. Conveniently use of various codes and standards in design and their application in designing new processes.
	4. Able to design various process equipment's and their requisite

	accessories as per standards.
	5. Able to do use of software's for design of equipment's.
iii) Course objectives:	Students will learn about
	1. The various aspects of mechanical design in the chemical process plant
	2. To Understand, Stresses upon the design and analysis of the basic process equipment viz. vessels, heat exchanger, distillation column, agitators, driers and evaporators etc.
	3. The course emphasizes on the development of design skills among the students to take design related decisions

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	3	2	-	-	1	-	-	-	-	1
CO2	3	2	1	1	-	-	-	-	-	-	-	1
CO3	2	3	3	2	-	-	-	-	-	-	-	1
CO4	2	3	3	2	-	-	-	-	-	-	-	1
CO5	2	2	2	2	3	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	**Design Prerequisite:** Materials of construction: Mechanical properties, Materials, Corrosion, Protective coating, Corrosion prevention, Choice of materials. Design codes, Maximum working pressure, Design pressure, Design Temperature, Design stress, Factors of safety, Selection of factor of safety design wall thickness, Corrosion ratio, Poisson ratio, Criteria of failure, Elastic stability.
Unit -II	**Design of Pressure Vessels:** Importance of chemical process equipment design, design procedure for pressure vessels subjected to internal pressure, external pressure and combined loading, closures for pressure vessels, optimum proportions of pressure vessels, optimum sizing of vessels Design of pressure vessels subjected to high pressure, monoblock construction, shrink fit construction.
Unit -III	**Process Design of Heat Exchanger**: Introduction, Types Of Heat Exchanger, Process Design of Shell and Tube Heat Exchanger. Process Design of plate type heat exchanger. Evaporator: Introduction, Types of Evaporators, Methods of Feeding of Evaporators, Design of Evaporator
Unit -IV	**Design of Distillation column:**

	Design of Sieve Tray for Distillation Column Design of Bubble Cap Tray for Distillation Operation. **Agitators:** Introduction, Types Of Agitators, Baffling, Power Requirements, Design Of Turbine Agitator.
Unit -V	**Design of Dryers: Introduction,** Type of Dryers, Design of Rotary Dryer. **Crystallizer Design**: Introduction, Types of Crystallizers, Design of crystallizers.
Text Book: M.V.Joshi, V.V. Mahajan, Design of Process Equipment Design, 3rd Edition, McMillan India.	
References books:	
1. B. C. Bhattacharya, Introduction to Chemical Equipment Design (Mechanical Aspects) CBS Publisher & Distributors, New Delhi. 2. Coulson & Richardson, Chemical Engineering (Vol VI), Pergamon Press. 3. R.E.Treybal, Mass Transfer Operations, McGraw Hill, New Delhi. 4. S.D. Dawande, Process Design of Equipments (Vol. 1& 2) Central Techno Publications, Nagpur. 5. G.K.Roy, Solved Problems In Chemical Engg., Khanna Publications, NewDelhi. 6. J.H.Perry, Chemical Engineer's Hand Book, McGrawhill, New Delhi.	

i) Title of course:	Numerical Methods in Chemical Engineering (PCC-CH304, Credit-03) **(L-02, T-0,P-02)**
ii) Course Outcomes:	1. Apply numerical methods to solve problems involving material and energy balances, fluid flow operations, heat and mass transfer, evaporation, thermodynamics and mechanical operations
	2. Determine roots of algebraic equations, solution of simultaneous equations and ordinary differential equations
	3. Solve problems using regression analysis, interpolation, extrapolation and numerical differentiation and numerical integration
	4. Able to write Computer programming in modular form & applicability of subroutines libraries to design modules.
iii) Course objectives:	Students will learn about
	Familiar with fundamentals of computer programming and application Study various numerical methods & able to solve problems related to unit operations.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	3	2	2	-	-	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	-	-	1
CO3	2	3	3	3	-	-	-	-	-	-	-	1
CO4	2	3	2	2	3	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	Systems of linear equation, solutions by methods of determinants, matrix inversion for solution of equations, Gauss elimination method.
Unit -II	Roots of algebraic and transcendental equation, iteration methods, Regula false method, Newton Rapson Method, roots of simultaneous and solution set of transcendental and algebraic equations. Development of equations for heat transfer, fluid mechanics and reaction engineering problems.
Unit -III	Elements of optimization techniques, single variable function, optimization direct search, with and without acceleration, method of regular intervals and Fibonacci search method, gradient methods.
Unit -IV	Computer programming in modular form, use of subroutine libraries, Block diagrams of preliminary aids in programming, capacity optimization.

Text books:

1. Jain, Iyengar, and Jain: Numerical Methods for Engineers and Scientists, Wiley Eastern,1995
2. Digital computation for Chemical Engineering by Leon Lapidas, MacGraw Hill, Latest Edition.

Reference:

1. S. D. Cante and C. de Boor, Elementary Numerical Analysis, an algorithmic approach, McGraw-Hill, 2000.
2. Gerald and Wheatley: Applied Numerical Analysis, Addison-Wesley, 1999.
3. Spiegel, M.R.; Theory and problems of Probability and statistics; McGraw-Hill Book Company; 1980.
4. K.S. Trivedi: Probability Statistics with Reliability, Queuing and Computer Science Applications, Prentice Hall of India Pvt. Ltd, 2000.

Lab work:

i) Ordinary Differential Equations
   1 Euler's Method
   2 Runge-Kutta Method
ii) Non Linear Differential Equations
   1 Regular Falsi
   2 Newton Raphson Method
iii) Linear Algebra
   1 Gauss Elimination Method
iv) Development Of Program Based On Numerical Techniques For Following Applications
   1 Heat Transfer
   2 Fluid Mechanics
   3 Reaction Engineering

i) Title of course:	Strength of Materials (PEC-CH305, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Understand the use of basic concepts of Resolution and composition of forces.
	2. Analysis of the beams, truss or any engineering component by applying conditions of equilibrium
	3. Understand the different stresses and strains occurring in components of structure
	4. Calculate the deformations such as axial, normal deflections under different loading conditions.
iii) Course objectives:	Students will learn about
	1. To impart basic knowledge on various industrial engineering materials and their properties
	2. To analysis of various lamina and solids for locating their centre of gravity and calculating their moment of inertia
	3. To provide the knowledge about stress & strain and its phenomena and to provide a fundamental knowledge on the design aspects of beams, columns and shells.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	2	-	-	-	-	-	-	-	1
CO2	2	3	3	3	-	-	-	-	-	-	-	1
CO3	3	3	2	2	-	-	-	-	-	-	-	1
CO4	3	3	2	2	-	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	Phase Diagrams & Properties of Engineering Materials: Gibb's Phase rule : Unary and Binary phase diagrams , Al2O3 - Cr2O3 , Pb-Sn, Ag-Pt and Iron- Iron Carbide Phase Diagram – Lever rule – Invariant reactions – TTT diagrams – Micro structural changes – Nucleation and growth – Martensitic transformations – Solidification and Crystallization – Recrystallization and Grain growth Properties of materials: Mechanical, Physical & Chemical properties. Industrial Engineering Materials – Ferrous & Non Ferrous metals & alloys – Introduction to various heat treatment processes & Mechanical tests
Unit -II	**Simple Stress and Strain:** Introduction to elasticity – Stress & Strain – Types of stresses & strain – Stress Strain curve and relationship – Hooke's

	law – Modulus of Elasticity & Modulus of Rigidity. Deformation of a body due to force acting on it – Deformation of a body due to self-weight. Principle of Superposition – Stress & Strain analysis in bars of varying sections and bars of different section – Stresses in bars of uniformly tapering sec
Unit -III	**Centre of Gravity & Moment of Inertial:** Introduction to Centroid & Centre of Gravity – Methods of Centre of gravity for Simple figures – Centre gravity of plane figures by geometrical consideration – Centre of gravity by method of moments for symmetrical & unsymmetrical lamina – Centre of gravity for solids and cut sections Concept of Moment of Inertia & Methods for Moment of Inertia – Moment of Inertia for Rectangular sections
Unit -IV	**Shear Force & Bending Moment Diagrams:** Introduction to Beams – Types of Loading – Shear force and Bending Moments – Sign conventions – SFD & BMD for Cantilever beams and simply supported beams with point loads, UDL and UVL.
Unit -V	**Thin cylindrical & Spherical Shells:** Introduction – Fracture of a cylindrical shell due to internal pressure, stress in thin cylindrical shell – circumferential & longitudinal stress. Design of thin cylindrical shells – change in dimensions of thin cylindrical shell due to internal pressure – change in volume due to internal pressure
Text books: Raghavan V, "Materials and Engineering" Prentice Hall of India, New Delhi (2006)	
Reference:	
1. Bansal R K, "Text book of Strength of Materials", Lakshmi Publications, New Delhi. 2. Khurmi R S, "Strength of Materials", S Chand Publications, New Delhi (2007). 3. William A.Nash, Theory and Problems of Strength of Materials, Schaum's Outline Series. McGraw Hill International Editions, Third Edition, 1994.	

i) Title of course:	Plant Utility (PEC-CH306, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Able to State the principle involved during water treatment, generation of steam and its uses, refrigeration cycles.
	2. Understand the concepts of different equipment's used to run the process plant with different utilities.
	3. Understand basic calculation involved in the utility generation units, and able to recognize colour code of systems.
	4. Acquire the knowledge for selection of different utilities.
iii) Course objectives:	Students will learn about
	1. The various process utilities in chemical industries.
	2. The importance of the various process plant utilities to run the plant

	smoothly.
	3. The steam generation and its distribution.
	4. The importance of steam economy and also the importance of insulation in any chemical plant.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	2	-	-	-	-	-	-	-	1
CO2	3	2	1	1	-	--	-	-	-	-	-	1
CO3	3	3	3	2	-	-	-	-	-	-	-	1
CO4	3	2	2	3	-	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	**Various process utilities:** their role and importance in chemical plants. Water Sources of water and their characteristics; Treatment storage and distribution of water; Sources of water, hard and soft water , Requisites of industrial water and its uses, Methods of water treatment, Chemical softening, Demineralization SS, Resins used for water softening 8 Reverse osmosis and membrane separation. Effects of impure boiler feed water & its treatments. Scale & sludge formation, Corrosion, Priming & foaming, Caustic embrittlement. Cooling purposes, drinking and process; Reuse and conservation of water; Water resource management
Unit -II	**Steam generation and Utilization***:* Steam generation and its application in chemical process plants, distribution and utilization :Problems based on enthalpy calculation for wet steam, dry saturated steam, superheated steam, steam economy, Steam condensers and condensate utilization Expansion joints ,flash tank design, steam traps their characteristics, selection and application, waste heat utilization.; Lagging, selection and thickness. Selection and Sizing of Boilers; Types of Boilers, Scaling, trouble shooting, preparing boiler for inspection, Boiler Act.
Unit -III	**Compressors, blowers and Vacuum Pumps:** Compressors, blowers and vacuum pumps and their performance characteristics; Methods of developing vacuum and their limitations, material handling under vacuum, Piping systems; Lubrication and oil removal in compressors and pumps. Air filters, Air and gas leakage. Inert gas systems, compressed air for process, Instrument air. Refrigeration cycles . Different methods of refrigeration used in industry. Vapour compression Vapour absorption: Lithium bromide (eco-Friendly). Different refrigerants, Monochlorodifluoro methane (R-22), Chlorofluorocarbons (CFC-Free), Secondary refrigerants: Brines Simple calculation of C.O.P. Refrigerating effects

Unit -IV	**Insulation**: Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and sub-zero temperatures, including cryogenic insulation.
Unit -V	**Psychometric:** Properties of Air-water vapours. Use of humidity chart, Equipment used for humidification, dehumidification, Evaporative cooling, spray ponds, cooling towers
Unit -VI	**Non Steam Heating System:** Thermic fluid heater, down therm heater, Temperature range, Principle and working

Text books and Reference books:

1. Nordell, Eskel, "Water Treatment for Industrial and Other Uses", Reinhold PublishingCorporation, New York.
2. Goodall, P. M., "The Efficient Use Of Steam" IPC Science and Technology
3. Lyle O. Efficient Use of Steam, 1963
4. S.T. Powel "Industrial water treatment" McGraw Hill, Newyork
5. Chattopadhya" Boiler operations" Tata McGraw Hill, New Delhi
6. P .N .Ananthanarayan Refrigeration & Air conditioning,Tata McGraw Hill.

i) Title of course:	Material Science and Engineering (PEC-CH307, Credit-03)**(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Gain basic knowledge and application of different type of materials.
	2. Understand the mechanical behaviour of materials and the science behind the failure.
	3. Get familiar with different heat treatment techniques.
	4. Capable to choose the types of corrosion and methods to prevent it.
iii) Course objectives:	Students will learn about
	1. Various solid engineering materials.
	2. The properties (electrical, mechanical, thermal etc) of different engineering materials.
	3. The manufacturing process of different engineering materials and the operations involved in it.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	1	1	-	-	-	-	-	-	-	1
CO2	3	2	1	2	-	-	1	-	-	-	-	1
CO3	3	2	1	2	-	-	-	-	-	-	-	1
CO4	3	2	3	3	-	-		--	-	-	-	1

v) Course Content:	
Unit -I	**Ferrous Metals:** Important varieties of iron ores. Cast iron: types, Mechanical, Thermal and Electrical properties and uses of cast iron. Pig iron: Types of pig iron. Wrought iron: Mechanical, Thermal and Electrical properties and uses of wrought iron. Steel: factors affecting physical properties of steel and uses of steel (No manufacturing process).
Unit -II	**Non Ferrous Metals:** Aluminium, cobalt, copper, lead, magnesium, nickel, tin and zinc their properties and uses. Mechanical, Thermal and Electrical Properties
Unit -III	**Alloys:** Introduction to Phase-Diagrams of metals and its alloys; Fe-Fe3C; Cu-Ni, Cu-Zn, Al- Cu equilibrium diagrams, methods of improving strength, and applications of metals and alloys. Mechanical, Thermal and Electrical Properties.
Unit -IV	**Glass:** Definition, classification, composition, types and Thermal and Electrical Properties of glass.
Unit -V	**Polymers:** Introduction, Classification, Polymerization, Polymerization techniques, molecular weights of polymers crystallinity in polymers, structural and technological function of polymers, Degradation of polymers, Additives for polymers, Biopolymers Nylon-66, nylon-6, polyesters, polycarbonates, polyurethanes', PVC, polypropylene, rubber
Unit -VI	**Phase Deformation:** Single phase metal deformation, failure of metals
Unit -VII	**Composite Materials & Nano Materials** : Classification, Constituents of composites, fibers, glass fibers Carbon fibers, Aramid fibers, Semiconductors ,Super conductors, Surface Modifications using linings of plastics, rubber, glass, ceramics with special reference to the applications in Chemical Industries. Introduction, Classification of nano materials, fullerenes, and inorganic nano particles, applications.

Text books and Reference books:

1. Materials in Industry by W J Patton, Prentice Hall Publication.
2. Introduction to Engineering Materials by Aggrawal, Tata McGraw Hill Publication.
3. Material Science by Narula, Tata McGraw Hill Publication.
4. Elements of Metallurgy by H S Bawa, Tata McGraw Hill Publication.
5. Materials Sci&Engg. By William D.Callister, Jr, An introduction by Willy International.
6. Material Science &Metallurgy by O.P. Khanna, Dhanput Rai Publication.
7. Material Science and Engineering by V.Raghavan, Prentice Hall.

i) Title of course:	Advance Fermentation Technology (PEC-CH308, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Able to devise the isolation and improvement methods base on metabolic pathways of products.
	2. Ability to design, formulate and sterilize the media for different inocula on large scale.
	3. Able to understand design and operation of basic control loops with respect to fermentation process.
iii) Course objectives:	Students will learn about
	1. This course helps students to understand various requirements in the fermentation industry like measurement of variables, process control, modelling and simulation of fermenters.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	1	-	-	-	-	-	-	-	1
CO2	2	3	3	3	1	-		-	-	-	-	1
CO3	2	3	3	3	-	-	1	-	-	-	-	1

v) Course Content:	
Unit -I	**Fermentation Processes and Parameters:** General requirements of fermentation processes and an overview, configuration of fermentor and ancillaries, main parameters to be monitored and controlled in fermentation processes.
Unit -II	**Media Design for fermentation process:** Criteria for good medium, medium requirements for fermentation process, points to be considered in selection of different nutrients including oxygen, formulation of optimal growth and product formation , examples of simple and complex media, design of various commercial media for industrial fermentation- medium optimization methods.
Unit -III	**Sterilization of media:** Over view on fermentation technology, history of development of fermentation industry, Introduction, Design of bath sterilization processes-calculation of Del factor, holding time, Rechards rapid methods for sterilization cycles, design of continuous sterilization processes, sterilization of fermenters, feeds liquid wastes, filter sterilization media, air, exhaust air, theory and design of depth filters

Unit -IV	**Instrumentation for Measurement and Control of Variables** Introduction to process variables, instruments used for measurement and control of temperature, flow measurement and control, measurement and control of pressure, rate of stirring, control of foam, oxygen and pH.
Unit -V	**Production of value added compounds from renewal sources** Productions of primary and secondary metabolites: Biopolymers Biodeseal, Bioethanol, amino acids, antibiotics

Text books and Reference books:

1. Peter F. Stanbury J. Hall & A. Whitaker," principles of fermentation Technology" , pergamon.1995
2. Scragg A. H "Bioreactors in Biotechnology" , Edited Ellis Horwood limited England1991.
3. Pauline M Doran, "Bioprocess Engineering Calculation.

i) Title of course:	Instrumentation and Analytical Techniques (OEC-CH309, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. To Understand application tools for quantitative and qualitative analysis
	2. The students will understand basic fundamental and operating principle for different analytical instruments like GC, GCMS, LC, LCMS, FTIT, UV-Vis etc.
	3. Understand principles of thermogravimetry and differential thermal analyses.
	4. Understand the data processing acquisition and validation techniques
iii) Course objectives:	Students will learn about
	1. To understand the fundamental analytical chemistry for instrumentation
	2. To understand the basic processes used in Instrumental Analytical Techniques
	3. Introduce the student to the techniques of troubleshooting instruments in the chemical laboratory.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	3	2	2	-	-	1	-	-	-	-	1
CO2	3	2	3	2	3	-	-	-	-		-	1
CO3	3	2	3	3	2	-	1	-	-	-	-	1
CO4	2	2	2	3	2	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	An introduction to analytical chemistry: choice of analytical methodology, sampling, sample preparation, chemical analysis, tools for quantitative chemical analysis, quality assurance.
Unit -II	Introduction to Chromatography, high-pressure liquid chromatography (HPLC), gas chromatography (GC) and other chromatographic methods. Detector types with a focus on mass spectrometry and hyphenated techniques such as GC-MS and LC-MS.
Unit -III	UV-Visible Spectrophotometry and Fluorescence Beer-Lambert's law, limitations, Molecular fluorescence, influencing factors, basic instruments, standardization, quantitative methods, Applications.
Unit -IV	Atomic spectrometry, atomic absorption, X-ray fluorescence methods Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, X-ray fluorescence principle, Instrumentation, quantitative analysis.
Unit -V	Thermo-analytical methods Thermogravimetry, Differential thermal analysis, differential scanning calorimetry, Principle, Block diagram, Applications, Quantitative determinations.
Unit -IV	Introduction to data processing, errors in chemical analyses, statistical analyses (including chemometrics) and data presentation. Method development, evaluation, validation, and QA/QC measures. Uncertainty analysis.

Text books and Reference books:

1. Instrumental Methods of Analysis: Willard, Merritt Dean.
2. Instrumental Methods of Chemical analysis-Anand Chatwal
3. Instrumental methods of chemical analysis – B.K. Sharma.
4. Harris, D.C., Quantitative Chemical Analysis, 7th Edition, W.H.Freeman, and company, New York 2006.
5. McNair, H. M., and Miller, J. M., Basic Gas Chromatography, 1 st Edition, John Willy and Sons, Inc, Singapore, 1998.
6. Palvia D. L., Lampman G. M., Kriz G. S. and Vyvyan J. R., Introduction to Spectroscopy, 4th Edition, Brooks/Cole, Belmont USA, 2009.
7. Snyder L. R, and Kirkland J. J., Introduction to Modern Liquid Chromatography, 2 nd Edition, A Wiley Interscience Publication, New York, 1979.

i) Title of course:	Air Pollution and Control (OEC-CH310, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Students would be able to understand the type and nature of air pollutants, the behavior of plumes and relevant meteorological determinants influencing the dispersion of air pollutants.
	2. Students would get exposure to air pollution engineering problems.
	3. The basic understanding of methods available for controlling point, line and area sources.
	4. Know the design characteristics of Electrostatic Presipitators, Fiber Filters, Cyclones, and Gravity Settlers for the removal of fine particulates.
iii) Course objectives:	Students will learn about
	1. Students would get an insight into the dispersion of air pollution in the atmosphere.
	2. Students would understand the control methodologies of several pollutants viz. SOx, NOx, CO, HC etc.
	3. To understand the principles of air pollution control equipments.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	3	2	1	1	2	1	-	-	-	1
CO2	2	3	3	2	1	-	1	1	-	-	-	1
CO3	2	3	3	2	1	-	1	1	-	-	-	1
CO4	2	2	3	3	1	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	Air Pollution Definitions, Scope, Significance and Episodes, Air Pollutants Classifications, Natural and Artificial, Primary and Secondary air pollutants, Point, Line and Areal Sources of air pollution, Stationary and mobile sources, Effects of Air pollutants on man, material and vegetation, Global effects of air pollution, Green House effect, Heat Island, Acid rains, Ozone Holes etc.
Unit -II	Meteorology and plume Dispersion, Properties of atmosphere, Heat, Pressure System, Winds and moisture, plume behavior and plume Rise Models, Gaussian Modal for Plume Dispersion. Control of particulates, Control at Sources, Process Changes, Equipment modifications, Design and operation of control. Equipment's: setting chambers, cyclone separators, filters, Dry and Wet scrubbers, Electrostatic preceptors.
Unit -III	Control of gaseous emissions, General Methods of control of NOx and

	SOx emissions, In plant Control Measures, process changes, dry and wet methods of removal and recycling, Adsorption, Absorption and Combustion.
Unit -IV	Air Quality Management, Monitoring of SPM, SOx; NOx and CO Emission standards, Air sampling, Sampling Techniques, High volume air sampler, stack sampling, Analysis of Air pollutants, Air quality standards, Air pollution control act.

Text books and Reference books:

1. Air pollution By M.N.Rao and H.V.N.Rao – Tata Mc Graw Hill Company
2. Air pollution By Wark and Warner – Harper & Row, New York.
3. An introduction to Air pollution by R.K Trivedy and P.K Goel, B.S.

i) Title of course:	Corrosion Engineering (OEC-CH311, Credit-03) **(L-03, T-0,P-00)**
ii) Course Outcomes:	1. Understand the principles of corrosion
	2. Determine corrosion rates for industrial equipment and metallic structures.
	3. Calculate corrosion rates using electrochemical work station.
	4. Understand corrosion resistant coatings, oxide layers.
iii) Course objectives:	Students will learn about
	1. Principles of corrosion and its impact on economy.
	2. Sample preparation and testing methodology.
	3. Various corrosion preventation tequniques and application of modern theory for evaluation of alloy materials.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	1	2	-	-	2	-	-	-	-	-	-	-
CO2	1	2	1	-	-	-	-	-	-	-	-	-
CO3	1	1	1	1	-	2	-	-	-	-	-	-
CO4	1	2	1	1	-	-	-	-	-	-	-	-

v) Course Content:	
Unit -I	Introduction & Corrosion Principles: Definition of corrosion, impact on economy, Electrochemical reactions, Corrosion rate expressions, Polarization, Passivity, Metallurgical aspects.

Unit -II	Eight Forms of Corrosion: Galvanic corrosion, crevice corrosion, pitting, intergranular corrosion, erosion corrosion, stress corrosion, hydrogen damage
Unit -III	Corrosion testing: Specimen preparation, exposure tests, open corrosion potential, linear polarization, Tafel slopes, corrosion current, stress corrosion, slow-strain-rate tests AC impedance.
Unit -IV	Corrosion Prevention: Cathodic protection, sacrificial anode methods of corrosion prevention, Anti-corrosion coatings.
Unit -V	Modern Theory-Principles & Applications: Alloy evaluation, Nobel metal alloying, velocity effects, galvanic coupling.

Text books and Reference books:

1. Fontana M, Corrosion Engineering, 3rd edition, Tata McGraw Hill Education Pvt. Ltd., 2010.
2. Pierre Roberge, Corrosion Engineering: Principles and Practice, 1st Edition, McGraw Hill, 2008.
3. Denny A. Jones, Principles and Prevention of Corrosion, 2nd Edition, Pearson-Prentice Hall, 2005.

i) Title of course:	In plant Training*(SII-CH312, Credit-01) (**L-00, T-0,P-00)**
	Students will go for in plant training of 3-4 weeks during winter vacations and their evaluation will be done in **sixth semester**.
ii) Course objectives:	Students will learn about
	1. Students will get exposure of industry environment.
	2. Students will get more knowledge of various unit operations run by industry.
	3. Students will get exposure to various processes of chemical plant.

Syllabus of course: **Semester VI**

i) Title of course:	Process Dynamics and Control (PCC-CH321, Credit-04) **(L-03, T-0,P-02)**
ii) Course Outcomes:	1: Evaluate the dynamic behaviour of processes
	2: Analyse stability of feedback control system
	3: Design PID controllers
	4: Determine frequency response for controllers and processes
	5: Apply advanced control schemes for processes
	6: Identify the characteristics of control valves
iii) Course objectives:	
	1. System Dynamics and concepts of dynamic response and representation of dynamic systems by equations and by transfer functions in block diagrams.
	2. Methods of solving linear, constant-coefficient ODEs by Laplace transform and numerical methods.
	3. Estimation of the stability limits for system, with or without control
	4. Process of enhancing, feedback control with cascade, feed forward, and model-based structures.
	5. Fundamentals of sensors, valves, transducers, controllers.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	1	1	-	-	-	-	-	-	1
CO2	3	2	2	2	2	-	-	-	-	-	-	1
CO3	2	3	3	3	1	-	-	-	-	-	-	1
CO4	2	3	3	3	1	-	-	-	-	-	-	1
CO5	3	2	2	3	2	-	-	-	-	-	-	1
CO6	2	2	3	3	2	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	Introduction to process control. Laplace transforms. Response of first order systems: Transfer Function, Transient Response, Forcing Functions and Responses. Examples of first and second order systems. Linearization, Transportation Lag. State space models – linear and nonlinear models.

	Linearization.
Unit -II	Components of a control system, Development of Block Diagrams, Controllers and Final Control Elements. Closed loop Transfer functions: Standard Block-Diagram Symbols, Transfer Functions for Single-Loop Systems and Multi-loop Systems.
Unit -III	Transient response of simple control systems: Servo Problem, Regulatory Problem, Controllers: Proportional, Proportional-Integral, PID Controllers. Ziegler-Nichols and Cohen-Coon Controller Settings. Model based controller design methods: direct synthesis method and IMC method.
Unit -IV	Stability: Routh Test and Root Locus Techniques. Introduction to frequency Response: Substitution Rule, Bode Diagrams. Control system design based on frequency response: Bode and Nyquist Stability Criterion, Gain and Phase Margins.
Unit -V	Advanced Control Strategies: Cascade Control, Feed-forward Control, Ratio Control, Dead-Time Compensation (Smith Predictor), Split Range Control. Control Valves: Types of Control Vales, Valve Sizing, Valve Characteristics, Valve Positioner.

Text book:

Stephanopoulos G., Chemical Process Control, an Introduction to Theory and Practice, PHI LearingPvt. Ltd. New Delhi

Reference books:

1. Babatunde A., Ogunnaike& Ray W.H.; Process Dynamics, Modeling and Control, Oxford Press, New York, (1994).
2. Coughnowr D.R.; Process Systems Analysis and Control: 2Nd Edition McGraw Hill Book Co.
3. Harriot P.; Process Control, McGraw Hill, New Delhi, 1984.
4. Perry R.H.; Chemical Engineer's Handbook, 7thEdition.
5. Radhakrishnan V.R.; Instrumentation and Control for the Chemical Mineral and Metallurgical Processes, Allied Publishers Ltd., New Delhi.
6. Smith Carlos A. &Corrieio A.B.; Principles and Practice of Automatic Process Control: 2nd Edition, John Wiley & Sons, New York

Lab work:

1. Study the first order system and determination of time constant for first order system.
2. To study the second order interacting and non-interacting system and determination of time constant, overshoot and decay ratio.
3. To study the gain of proportional controller.
4. To study process simulation.
5. To study of PI controller.
6. To study the PID Controller.

7. To study proportional controller
8. Calibration and determination of time lag of various first and second order instruments
9. Set point setting and study of operation of the system and set point setting
10. Study of safety valve actuating system.
11. PC based control of any of equipment ex Heat Exchanger/ Distillation column.
    Flow control study using P,P-I,P-I-D, Controllers.
    Note: **Total Experiments to be conducted/designed: 8**

i) Title of course:	Chemical Reaction Engineering-II (PCC-CH322, Credit-04) **(L-03, T-0,P-02)**
ii) Course Outcomes:	1. Able to understand concepts flow pattern, RTD of fluid reactors and F,C,E curve.
	2. Ability to understand the spectrum of kinetics, rate equation and pore diffusion effects, product distribution in multiple reactions.
	3. Analyse the problems of mass transfer with reaction in solid catalysed reactions and deactivation reactions.
	4. Application and evaluation of design and mass transfer phenomenon with chemical reaction in fluid-fluid reactions.
	5. Able to understand, develop, apply various models for solid particle reactions and find out rate controlling steps in case of solid fluid reactions.
iii) Course objectives:	Student can learn about
	1. Basic concepts of Flow Pattern, Contacting, and Non-Ideal Flow & dispersion model.
	2. Fundamentals of Heterogeneous Reactions & solid catalysed reactions, Spectrum of kinetic regimes, Surface kinetics and rate equation, pore diffusion, porous catalyst, Heat effects
	3. Concepts and application of Catalyst and Catalytic Reactors
	4. Kinetics and Design of Fluid- Fluid Reactions and Fluid- Particle Reactions

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	1	-	-	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	-	-	1
CO3	2	3	3	2	-	--	-	-	-	-	-	1
CO4	2	3	3	3	-	-	-	-	-	-	-	1
CO5	3	3	3	2	1	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	**Flow Pattern, Contacting, and Non-Ideal Flow:** Non ideal flow in reactors, RTD of fluid in reactors, Age distribution, F curve, C curve and E curve, Compartment model, Dispersion model, Tank in Series model, Problems.
Unit -II	**Introduction to Heterogeneous Reactions:** Examples of heterogeneous reactions, contacting pattern and flow modelling, Problems
Unit -III	**Solid Catalysed Reactions:** Introduction and Spectrum of kinetic regimes, Surface kinetics and rate equation, pore diffusion, porous catalyst, Heat effects, Performance Equation, Experimental methods and rate equation, Controlling Resistance, Product distribution in multiple reactions, Problems.
Unit -IV	**Introduction to Catalyst and Catalytic Reactors:** Typical Catalysts, Catalyst Characterizations, Catalyst Deactivation and Regeneration, Packed bed reactor, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors etc. Hydrodynamic Cavitations. Problems.
Unit -V	**Kinetics and Design of Fluid- Fluid Reactions:** The rate equation, Kinetic regimes for mass transfer and reaction, Fast reaction, Intermediate reaction, Slow Reactions, Factors to select the contactor, Straight mass transfer, Various cases of mass transfer with chemical reaction, reaction kinetics, Problems.
Unit -VI	**Kinetics and Design of Fluid- Particle Reactions:** Various models for fluid-solid reactions, Shrinking core model, Rate of reaction, Reaction/Mass transfer Control, Rate controlling steps, plug flow and mixed flow of solids, Problems.

Text book:

Levenspiel, "Chemical Reaction Engineering", 3rd Edn., Wiley Easter Ltd. New York,1999

Reference books:

1. J.M. Smith, “Chemical Engineering Kinetics", 3rd Edn., McGraw Hill, New York, 1981.
2. Arora,Heat Transfer and Mass Transfer, Khanna Publishers, New Delhi. .
3. Badger W.L., Banchero J.T.; Introduction to Chemical Engineering,McGraw Hill Book Co.New York. .
4. Brown G.G.; Unit Operations, John Wiley & Sons, New York.
5. Chattopadhyay P., Unit Operations in Chemical Engineering Vol-I &II,Khanna publishers, New Delhi.
6. Coulson J.M., Richardson J.F.; Chemical Engineering Vol.II, edition 3rd, Perganon Press, New York.

Lab work:

1. To determine the effect of residence time on conversion and to determine the rate constant by using plug flow reactor.
2. To determine the effect of residence time distribution on conversion and to determine the rate constant by using CSTR.

3. Determination of residence time distribution and dispersion number for packed bed reactor. 4. Study of saponification reaction in combined reactor. 5. To study the kinetic of emulsion polymerization of styrene in a batch reactor under isothermal condition. 6. To study of a non-catalytic homogeneous reaction in series arrangement of PFR and CSTR. 7. To study of a catalytic homogeneous reaction in a batch reactor under adiabatic condition. 8. Catalytic hydrolysis of ethyl acetate in spinning basket reactor (for batch operation). 9. Catalytic hydrolysis of ethyl acetate in spinning basket reactor (for continuous operation). 10. Studying the kinetics of Etherification reaction. Studying the kinetics of Neutralization reaction Note: **Total Experiments to be conducted/designed: 8**

i) Title of course:	Plant Design & Economics Management (PCC-CH323, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Able to Develop plant layout drawings that will help in installation procedures of new process plants.
	2. Capable to understand the basic engineering fundamentals that include process selection, flow sheet preparation and economics of the particular process plant.
	3. Understand the basic concepts of cost estimation and profitability analysis of process plants.
	4. Able to understand the process equipment design concepts and perform various optimization techniques to optimize various parameters such as heat duty of heat exchanger, production rate of various process plants.
iii) Course objectives:	Student can learn about
	1. Chemical Engineering Plant Design includes all engineering aspect involved in the development of either a new, modified, or expanded industrial plant.
	2. To study the development of all overall design projects involves many different design considerations & laws.
	3. Cost estimation means all cost required for industrial operation; its factors affecting different types of investment & production costs.
	4. Project feasibility tested by economic profitability evolutions by various techniques and optimum design considerations approach

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	3	1	1	-	-	-	-	-	-	1
CO2	3	2	3	1	1	-	-	-	-	-	-	1
CO3	3	2	2	2	1	-	1	1	1	1	1	1
CO4	3	2	2	2	1	-	1	1	1	1	1	1

v) Course Content:	
Unit -I	**Introduction to the Chemical Engineering Plant Design:** Process design development; cost estimation; Factors affecting Profitability of investment; optimum design; practical consideration of design; design approach; process design development; design-project procedure; flow diagrams; preliminary design; comparison of different processes; scale-up in design; safety factors; computer Aided Design.
Unit -II	**General design consideration**: Plant location, plant site, plant layout; plant operation & Control; utilities; structural design; storage; material handling; Waste disposal; pollution control; cost &asset Accounting; outline for accounting procedure; Basic relationship in accounting; Balance Sheet; income statement; cost accounting methods; numerical
Unit -III	**Cost Estimation:** Cash flow for industrial operation; factors affecting investment & production cost; Capital investment (CI); Estimation Of CI; Cost Index; Cost Factors in CI; Estimation Of TPC; Interest &Investment Cost; type of Interest; Normal &effective Interest Rates; Continuous Interest; present worth & discount; annuities; Numerical.
Unit -IV	**Depreciation and Profitability**: Types of depreciation; service life; Salvage life; Present Value; Methods to determine Depreciation; straight line method; Declining Balance Method; Sum-of-year-digits method; Sinking Fund method; Numerical; Profitability, alternative investments and replacements; profitability standards; Discounted Cash flow; numerical.
Unit -V	**Optimum Design & Design Strategy**: Incremental Cost; Intangible &Practical Considerations; General procedure for determining optimum conditions; the break-even chart for production schedule & its significance for optimum analysis; optimum production rate in plant operation; optimum conditions for cyclic operations; Accuracy & sensitivity of results; the strategy of linearization for optimization analysis; numerical.

Text book: Max S. Peters, Klaus D. Timmerhaus; Plant design & Economics for Chemical Engineers; McGraw Hill International Book Company, New Delhi.
Reference books:
1. F.C. Vilbrandtand C.E. Dryden, Chemical Engineering Plant Design; McGraw Hill, International Book Company 2. Perry's Chemical Engineer's handbook.

i) Title of course:	Chemical Process Industries (PCC-CH324, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Students can understand synthesis and production process of the required product.
	2. Students can understand flow diagram with various Instrumentation and Process symbols.
iii) Course objectives:	Student can learn about
	1. the advancement in chemical process industries and its application to chemical engineering
	2. Able to draw the process flowsheets with reactions.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	2	1	-	1	1	-	-	-	1
CO2	3	2	2	2	3	-	1	-	-	-	-	1

v) Course Content:	
Unit -I	Introduction and overview of Chemical Process Technology. Preparation of process flow diagrams, Instrumentation diagrams, and Process symbols.
Unit -II	Petroleum refinery processes: Introduction to crude oil, Crude refining processes (i) physical processes (Desalting/dehydration, Crude distillation, Propane deasphalting Solvent extraction and dewaxing, Blending, (ii) Chemical process (thermal process – Visbreaking, Delayed coking, Flexicoking), Catalytic Processes – Hydrotreating, Catalytic reforming, Catalytic cracking, Hydrocracking, Catalytic dewaxing, Alkylation, Polymerization, Isomerization
Unit -III	Petrochemical Industries: production of petrochemical feedstocks, olefins, and aromatics, intermediates from olefins and aromatics. Manufacture of ethylene, propylene, butylenes, benzene, toluene etc.
Unit -IV	Inorganic Chemical Industries: chloro–-alkali industries, manufacture of acids-sulfuric, nitric, phosphoric acids, Fertilizers- ammonia, urea, Ammonium sulfate, ammonium nitrate, Urea, SSP and TSP

	and miscellaneous fertilizers.
Unit -V	Natural products -manufacture of sugar, starch, and its derivatives, Pulp, Paper, oil and fats, Rayon industries. Edible oils: extraction and refining, fat splitting, soaps, and detergents.
Unit -VI	Polymerization industries (ethylene, polyethylene, propylene, polypropylene, butylenes, benzene, toluene, PVC and polyester synthetic fibers etc.
Text book: 1. Dryden, Outlines of Chemical Technology, Edited and Revised by M.Gopala Rao and S. Marshall, 3rd Ed., Affiliated East-West, New Delhi, 1997.	
Reference books:	
1. T. G. Austin and S. Shreve, Chemical Process Industries, 5th Ed., McGraw Hill, New Delhi, 1984. 2. P. H. Groggins, Unit Processes in Organic Synthesis, 5th Ed., McGraw Hill, 1984.	

i) Title of course:	Polymer Technology (PEC-CH325, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Apply the techniques and their characteristics/limitations of synthesis of polymers.
	2. Identify the structure-processing-property relationship of polymers.
	3. Understand and apply the various processing and manufacturing techniques
	4. Understand the basic issues involved in polymer blends, composites and nano-composites.
iii) Course objectives:	Student can learn about
	1. To provide a broad and fundamental knowledge of the polymers and their chemical, physical and mechanical behavior.
	2. To impart the knowledge of various processing techniques along with the production of polymers
	3. The students will be able to correlate structure-processing-properties relationships for polymers, blends and composites including nanocomposites.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	1	1	1	-	-	-	-	-	-	-	1
CO2	3	1	2	2	1	-	-	-	-	-	-	1
CO3	3	1	1	1	1	-	-	-	-	-	-	1
CO4	2	1	2	2	1	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	Introduction: Comparison of thermoplastics and thermoset plastics; Thermoset plastics - Types of resins, Interpenetrating Polymer Networks (IPN); Thermoplastics - Types of aliphatic and aromatic thermo plastics, copolymers, Blends and alloys; Liquid crystal plastics; cellular plastics; oriented plastic materials.
Unit -II	Processing: Basics of process design, Classification & general aspects of processes - molding & forming operations, Post die processing; Decoration of plastics - Printing, Vacuum Metalizing, In-mold decoration. Additives & Compounding - Different types of additives, Batch mixers, continuous mixers, Dispersive and distributive mixing, Characterization of mixed state. Fundamentals on Viscous & Viscoelastic behavior of polymer melt, Rheological measurements and Polymer processability. Non isothermal aspects - Temperature effect on rheological properties, Crystallization, Morphology & Orientation, plastic memory, Molecular weight effects on processing and properties.
Unit -III	Properties & Testing of plastics: Basic concepts of testing, National & International standards, Test specimen preparation, Pre conditioning & Test atmosphere. Identification of plastics by simple test - Visual examination, Density, Melting point, Solubility test, Flame test, Chemical tests. Effect of shape & structure on material properties, Long - term & short - term mechanical properties, crazing, Permeability & barrier properties, Environmental-stress cracking, Melt flow index, Heat deflection temperature, Vicat softening temperature, Glass transition temperature, thermal conductivity, Co-efficient of thermal expansion, Shrinkage, Thermal stability, Flammability.
Unit -IV	Waste management & Recycling: Plastics waste and the associated problems, Integrated waste management - source reduction, recycling & sustainability correlation, energy recovering process. Environmental issues, policies and legislation in India.

Text book:

Gruenwald G, "Plastics - How Structure Determines Properties", Hanser Publishers, 1993

Reference books:

1. Baird D. G. and Collias D. I., "Polymer Processing Principles and Design", ButterworthHeinemann, 1995
2. Vishu Shah, "Hand Book of Plastics Testing Technology", John Wiley & Sons Inc. New York
3. J.S.Anand, K.Ramamurthy, K.Palanivelu, "How to identify Plastics by Simple Methods". CIPET, Chennai
4. Anthony L. Andrady (Ed.), "Plastics and the Environment", Wiley Interscience, New York

i) Title of course:	Advance separation Technology (PEC-CH326, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Understand equilibrium and rate governed multistage separation processes.
	2. Understand characterization of membranes and separation processes such as reverse osmosis, dialysis, ultra filtration, and electro dialysis.
	3. Able to determine the rate of permeate flux for gas permeation through polymeric membranes
	4. Study chromatographic separation techniques and molecular sieve separation techniques.
iii) Course objectives:	Student can learn about
	1. The various Membrane separation Processes and their characterizations.
	2. The principles and classifications Chromatographic process, reactive distillation and extraction
	3. To separate Racemic mixtures and also organic acids or bases by dissociation extraction

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	1	1	1	1	-	-	-	-	-	-	1
CO2	3	2	1	1	1	-	-	-	-	-	-	1
CO3	2	1	2	1	-	-	-	-	-	-	-	1
CO4	2	2	2	1	2	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	Membrane separation Processes, Desalination Technology, Reverse Osmosis, gas separation processes, electro – dialysis, adsorption processes.
Unit -II	Ion Exchange process technology, Chromatographic separation principles and operation, methodology and process design.
Unit -III	Separation of Racemic mixtures, and its applications, with specific mixtures. Reactive distillation process in kinetics, dissociation extraction, reactive extraction technology. Racemic Separations.
Unit -IV	Multi-component distillation technology for separation of pure components
Unit -V	Downstream processing in biochemical industries, protein purification, gel permeation chromatography, metal legend chromatography, dye ligand partitioning and chromatography, affinity chromatography

Text book & Reference books::

1. Sourirajan S.; Reverse Osmosis, Logos Press London, New York, 1970.
2. Gautam, R.G.; Membrane filtration, A Hilger Ltd., R. McLaren Bristol.
3. Product Recovery in Bioprocess Technology. BIOTOL (Project); Thames Polytechnic; Oxford, Boston, Butterworth Heinmann.
4. Perry R.H. and Green D.W., Perry's Chemical Engineering Handbook, VII Edition, McGraw Hill Book Co.
5. Richardson J.F.; Chemical Engineering Volume 2, 5th Edition, Tata McGraw Hill.

i) Title of course:	Membrane Technology (PEC-CH327, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. To understand the basic concepts of different membrane processes
	2. Should get familiar with several separation techniques to apply this knowledge in real life
	3. Able to differentiate membrane modules based on pore size, pattern and structure.
	4. Should capable to do the selection of appropriate membrane for industrial applications
iii) Course objectives:	Student can learn about
	1. Basic concepts of membrane processes
	2. Get idea about design equations and module design
	3. Mechanism of membrane transport and application

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	1	1	1	1	-	-	-	-	-	-	1
CO2	2	1	1	-	-	-	1	1	-	-	-	1
CO3	3	2	2	2	1	-	-	-	-	-	-	1
CO4	2	1	2	1	1	-	-	-	-	-	-	1

v) Course Content:	
Unit -I	**Introduction to Membranes technology**: Reverse osmosis, ultra filtration, micro filtration, permeability, desalination technology dialysis technique.
Unit -II	**Membrane modules and applications:** preparation of industrial RO, NF membranes, their membrane modules and applications.
Unit -III	**Design parameters:** Design principles, membranes selection and parameters to be considered in design of membranes separation technology
Unit -IV	**Mechanism of membrane transport:** Gaseous diffusion, Pervaporation,

	selective membranes for purification
Unit -V	**Electro membrane processes:** Basic aspects and applications

Text book & Reference books::

1. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4th Edition, Prentice Hall Inc., 2009.
2. McCabe W.L., Smith J.M.&Harriot P.; Unit Operations in Chemical Engineering, 5th Edition, McGraw Hill Book Co., New York, 1993.
3. J. M. Coulson and Richardson, Chemical Engineering, Particle Technology and Separation Processes,Vol. 2, 4th Edition, Elseiver India, 2006.

i) Title of course:	Fuel Cell Engineering (PEC-CH328, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Understand fuel cell fundamentals.
	2. Analyze the performance of fuel cell systems
	3. Understand construction and operation of fuel cell stack and fuel cell system.
	4. Apply the modelling techniques for fuel cell systems
iii) Course objectives:	Student can learn about
	1. The basic chemistry of fuel cell, thermodynamics and theoretical electrical work
	2. Fuel for fuel cells and Fuel electrochemistry
	3. Fuel cell design and processing

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	1	1	1	-	-	3	-	-	-	-	--
CO2	2	1	1	1	-	-	-	-	-	-	-	-
CO3	2	2	-	-	2	-	3	-	-	-	-	-
CO4	2	3	3	3	-	3	3	-	-	-	-	-

v) Course Content:	
Unit -I	Overview of Fuel Cells: What is a fuel cell, brief history, classification, how does it work, why do we need fuel cells, Fuel cell basic chemistry and thermodynamics, heat of reaction, theoretical electrical work and potential, theoretical fuel cell efficiency.
Unit -II	Fuels for Fuel Cells: Hydrogen, Hydrocarbon fuels, effect of impurities such as CO, S and others.
Unit -III	Fuel cell electrochemistry: electrode kinetics, types of voltage losses,

	polarization curve, fuel cell efficiency, Tafel equation, exchange currents.
Unit -IV	Fuel cell process design: Main PEM fuel cell components, materials, properties and processes: membrane, electrode, gas diffusion layer, bi-polar plates, Fuel cell operating conditions: pressure, temperature, flow rates, humidity. Main components of solid-oxide fuel cells, Cell stack and designs, Electrode polarization, testing of electrodes, cells and short stacks, Cell, stack and system modelling
Unit -V	Fuel processing: Direct and in-direct internal reforming, Reformation of hydrocarbons by steam, CO2 and partial oxidation, Direct electro-catalytic oxidation of hydrocarbons, carbon decomposition, Sulphur tolerance and removal, Using renewable fuels for SOFCs

Text book & Reference books:

1. Hoogers G., Fuel Cell Technology Hand Book, CRC Press, 2003.
2. Karl Kordesch& Gunter Simader, Fuel Cells and Their Applications, VCH Publishers, NY, 2001.
3. F. Barbir, PEM Fuel Cells: Theory and Practice, 2nd Ed., Elsevier/Academic Press, 2013.
4. Subhash C. Singal and Kevin Kendall, High Temperature Fuel Cells: Fundamentals, Design and Applications, 2003.
5. O'Hayre, R. P., S. Cha, W. Colella, F. B. Prinz, Fuel Cell Fundamentals, Wiley, NY 2006.

i) Title of course:	Project Planning & Management (OEC-CH329, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	
	1. Understand basics of Management science and their application in industry
	2. Able to understand importance of Techno-economic feasibility ,Process design –process selection. And analysis of different financial projects.
	3. Able to understand the basics of Design inventory control, scheduling a project using CPM/PERT.
iii) Course objectives:	Student can learn about
	1. Provide students with a basic understanding of project management principles and practices.
	2. Increase the student's ability to function effectively on a project team.
	3. Increase the student's ability to function effectively as a project manager.
	4. Improve the student's ability to communicate effectively both orally and in writing.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	1	1	1	-	1	-	-	-	-	1
CO2	2	2	3	3	-	-	1	1	-	-	3	1
CO3	2	2	2	2	1	-	-	-	-	-	2	1

v) Course Content:	
Unit -I	The World of Project Management: Project Management, Project Management vs General Management, Life cycles of projects, Project selection methods, Case studies, Examples
Unit -II	The Manager, The Organization and The Team: PM's role, PM's responsibilities to the project, Selection of project manager, Project management as a Profession, Fitting projects into the parent organization, Project team, Case studies
Unit -III	Planning the Project: The contents of a project plan, Planning process, Work breakdown structure, Multidisciplinary teams, Case studies
Unit -IV	Budgeting the Project: Methods of budgeting, Cost Estimating, Improving cost estimates, Budget uncertainty and risk management, Case studies.
Unit -V	Scheduling the Project: PERT and CPM networks, Project uncertainty and risk management, Simulation, Gantt chart, Extensions to PERT and CPM, Case studies.
Unit -VI	Allocating Resources to the Project: Expediting a project, Resource loading, Resource leveling, Allocating scarce resources to projects.
Text book & Reference books: 1. Mantel, Samuel, Meredith and others, Project Management: Core Text Book, Wiley India Pvt. Ltd.,1st Edition,2006. 2. S. Choudhary, Project Management, McGraw Hill India.	

i) Title of course:	Renewable Energy Sources (OEC-CH330, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Understand and analyze the present and future energy demand of world and nation.
	2. Understand the techniques to exploit the available renewable energy resources such as solar, biofuels, wind power, tidal and geothermal effectively.
	3. Know about the exploration of nonconventional energy resources and their effective tapping technologies
	4. Acquire the knowledge of modern energy conversion technologies
iii) Course objectives:	Student can learn about
	1. Study various types of conventional and non-conventional energy

	resources
	2. Describe new and renewable energy sources like solar energy, wind energy, geo-thermal energy, tidal energy, ocean thermal energy.
	3. Describe the principles and techniques used in energy conservation and management.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	2	1	1	1	1	-	-	-	1
CO2	2	3	2	2	1	-	2	-	-	-	-	1
CO3	2	2	2	2	1	1	2	1	-	-	-	1
CO4	3	2	2	2	1	1	1	1	-	-	-	1

v) Course Content:	
Unit -I	Introduction -: Energy scene of supply and demand in India and the world, Energy consumption in various sectors, potential of non-conventional energy resources, energy needs and energy supply, sources, contribution of non-conventional energy.
Unit -II	Solar Energy -: Solar radiation and its measurement, characteristics and estimation, limitations in the applications of Solar Energy, Collectors: flat plate and concentrating types, their comparative study; design and material selection, efficiency, selective paints and surfaces. Solar water heater, applications of Solar Energy for heating, drying, water desalination, solar concentrators, photovoltaic power generation using silicon cells. Thermal storages, Solar ponds, Solar pumps, Solar power, Solar cookers. Direct conversion of solar energy to electricity and its various uses, materials, limitations and costs.
Unit -III	Bio- Fuels -: Photosynthesis and generation of bio-gas, digesters and their design, selection of material; feed to digester, pyrolytic gasification, production of hydrogen, algae production and their uses.
Unit -IV	Wind Energy -: Principle of energy from wind, availability, site selection, different types of wind turbines, design criteria and material selection, economics. Geo-Thermal Energy- : Geotechnical wells and other resources dry rock and hot aquifer analysis, harnessing geothermal energy resources. Tidal Energy- : Its meaning, causes of tides and their energy 31 potential, enhancement of tides, limitations, different methods of using tidal power.
Unit -V	Ocean Thermal Energy -: Principles of ocean thermal energy conversion (OTEC) analysis and sizing of heat exchangers for OTEC
Unit -VI	Energy Conservation: Principles of energy conservation. Familiarization with the different energy conservation appliances and practices, improved cooking stoves, benefits of improved cooking stoves over the traditional cooking stoves. Scope of energy conservation in the domestic, commercial

	and agricultural sector.

Text book & Reference books:

1. Kothari D.P., "Renewable Energy Sources and Emeriging Technologies",PHI,2008
2. Khan B.H., "Non-Conventional Energy Sources",2nd edition, McGraw-Hill,2009
3. Solanki C.S., "Renewable Energy Technologies",PHI,2009
4. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, Delhi.
5. Twiddle J., Weir T., "Renewable Energy Resources", Cambridge University Press, 1986

i) Title of course:	Solid waste Management (OEC-CH331, Credit-03) **(L-03, T-0,P-0)**
ii) Course Outcomes:	1. Capable to understand the concepts of solid waste with methods of handling
	2. Use information related to types and composition of solid waste with methods of handling, sampling and storage of solid waste
	3. Analyze all methods and Select the appropriate method for solid waste collection, transportation, redistribution and Disposal
	4. Describe methods of disposal of hazardous solid waste.
iii) Course objectives:	Student can learn about
	1. Concepts related to solid wastes management.
	2. Know different storage techniques for solid waste, its impact on human health and environment
	3. Understand the fundamentals about solid waste collection and transfer.
	4. Learn the efficient management of solid wastes.

iv) Articulation Matrix:

PO/PSO ➡ ⬇ CO	1	2	3	4	5	6	7	8	9	10	11	12
CO 1	3	2	2	1	-	-	1	1	-	-	-	1
CO2	2	2	1	1	-	1	1	1	-	-	-	1
CO3	3	2	1	1	-	1	2	2	-	-	-	1
CO4	3	2	1	1	-	1	2	2	-	-	-	1

v) Course Content:	
Unit -I	Sources and types of municipal solid wastes Sources and types of solid waste - Quantity - Factors affecting generation of solid wastes; Characteristics - methods of sampling and characterization
Unit -II	Effects of improper disposal of solid Wastes - public health effects. Principle of solid waste management - social and economic aspects; Public awareness; Role of NGOs; Legislation. On-site storage and

	processing On-site storage methods - Materials used for containers - on-site segregation of solid wastes - Public health and economic aspects of storage - options under Indian conditions – Critical Evaluation of Options
Unit -III	Collection and transfer Methods of Collection - types of vehicles - Manpower requirement - collection routes; transfer Stations - selection of location, operation and maintenance; options under Indian conditions
Unit -IV	Off-site processing Processing techniques and Equipment; Resource recovery from solid wastes - composting, Incineration, Pyrolysis - options under Indian conditions
Unit -V	Disposal Dumping of solid waste; sanitary landfills - site selection, design and operation of sanitary landfills - Leachate collection and treatment

Text book & Reference books:

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil Integrated SolidWaste Management, McGraw-Hill Publishers, 1993.
2. B.Bilitewski, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, "Waste Management", Springer, 1994.
3. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2000.
4. R.E.Landreth and P.A.Rebers, Municipal Solid Wastes - problems and Solutions, Lewis Publishers, 1997.
5. Bhide A.D. and Sundaresan, B.B., Solid Waste Management in Developing Countries, INSDOC, 1993.

i) Title of course:	In plant Training (SII-CH312, Credit-01) **(L-00, T-0,P-0)**
ii) Course Outcomes:	1. Understand the various unit operations and related process of selective industries
	2. Able to express the knowledge of utility section
	3. Able to understand safety and legal laws of industries
	4. Understand applicability of human resource and materials management.
	Evaluation of industrial training program is based on report and viva.
ii) Course objectives:	Students will learn about
	1. To introduce the various unit operations and related process of selective industries.
	2. Exposure with various utility of process plant.
	3. Learn the safety and legal laws of industries
	4. Exposure with human resource and material management
iv)Content:	Students will undergo implant training for four or six weeks duration in selective industries during Ist semester (winter vacation) .They has to get exposure on various aspects of process industry. Also they have to prepare training report and attempt oral exam at the end of Second semester