Department of Chemical Engineering

Revised Syllabus

of

Final Year B.Tech.

Chemical Engineering

EDUCATION OF HUMAN POWER FOR TECHNOLOGICAL EXCELLENCE
उत्कृष्ट तंत्रज्ञानार्थम् जनशक्ती शिक्षणम्

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

Year 2021-22

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)

Final Year 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	3	1	2									
PEO2												
PEO3												
PEO4												

1-Low, 2-Middle, 3-High

Shri Guru Gobind Singhji Institute of Engineering and Technology, Vishnupuri, Nanded

DEPARTMENT OF CHEMICAL ENGINEERING

Curriculum Structure of B. Tech.
(With effective from 2021-2022)

Semester VII						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PCC-CH401	Process Equipment Design & Drawing-II	02	01	--	03	--
PCC-CH402	Process Modeling & Simulation	03	--	02	03	01
PCC-CH403	Transport Phenomena	03	--	--	03	--
HMC-CH404	Industrial Organization & Management	03	--	--	03	--
PEC-CH4**	Elective-III	03	--	--	03	--
SEM-CH410	Seminar	--	--	02	--	01
PRJ-CH411	Minor Project	--	--	08	--	04
	Total	**14**	**01**	**12**	**21**	
Semester VIII (Scheme-A)						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PEC-CH4**	Elective-IV	03	--	--	03	--
OEC-CH4**/ OEC-**4**	Elective-V	03	--	--	03	--
PRJ-CH425	Major Project	--	--	16	--	08
	Total	**06**	**--**	**16**	**14**	
SemesterVIII (Scheme-B)						
Course Code	**Name of the course**	**L**	**T**	**P**	**Credits**	
					Th	**Pr**
PRJ-CH426	Major Project	--	--	28	--	14
	Total	**--**	**--**	**28**	**14**	

L – No. of Lecture Hours/week, T – No. of Tutorial Hours/week, P – No. of Practical Hours/week

B.Tech.(CHEM)	Contact Hours	Credits
TOTAL	49/55	35

Elective-III		
Sr. No.	Course code	Course Name
1.	PEC-CH405	Piping Engineering
2.	PEC-CH406	Optimization Techniques
3.	PEC-CH407	Computational Fluid Dynamics
4.	PEC-CH408	Catalytic Science and Engineering
5.	PEC-CH409	Sustainable Chemical Technology

Elective-IV		
Sr. No.	Course code	Course Name
1	PEC-CH413	Nanotechnology
2	PEC-CH414	Refining Science and Engineering
3	PEC-CH415	Safety and Risk Analysis
4	PEC-CH416	Polymer Processing
5	PEC-CH417	Green Chemistry

Elective-V		
Sr. No.	Course code	Course Name
1	OEC-CH418	Waste Water Treatment
2	OEC-CH419	Energy Management
3	OEC-CH420	Renewable Energy Resources
4	PEC-CH421	Food Technology
5	OEC-CH422	Solid Waste Management
6	OEC-CH423	Green Process Engineering
7	OEC-**4**	Institute Open Elective (Offered by other dept. /MOOC)

Syllabus of course: **Semester VII**

i) Title of course:	Process Equipment Design & Drawing-II (PCC-CH401) Credits: 03 (L-2, T-1, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	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. Conveniently use of various codes and standards in design and their application in designing new processes.
	3. Able to design various process equipment's and their requisite accessories as per standards.
	4. Able to simulate the process parameters
iii) Course objectives	Students undergoing this course will be able to-
	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) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	**Introduction to Separation Processes:** Solid-Solid Separations, Liquid-Solid (Solid-Liquid) Separators, Liquid-Liquid Separation, Gas-Solid Separations (Gas Cleaning), Gas-Liquid Separators, Transport and Storage of Materials, Reactors
Unit -II	**Heat Exchangers Design:** Introduction, Types Of Heat Exchanger, Process Design of Double pipe, Shell and Tube Heat Exchanger and plate type heat exchanger.
Unit -III	**Design Of Distillation Column:** Design of Sieve Tray for Distillation Column, Design of Bubble Cap Tray for Distillation Operation. Sequencing of Columns, Estimation of Reflux and Number of Trays (Fenske-Underwood-Gilliland Method), Minimum Trays calculation

Unit -IV	**Dryers And Cooling Towers:** Classification and General Characteristics of Dryers, Batch Dryers, Continuous Tray and Conveyor Belt Dryers, Rotary, Cylindrical Dryers, Drum Dryers for Solutions and Slurries, Pneumatic Conveying Dryers, Fluidized Bed Dryers, Spray Dryers, Thermal Efficiency & Design Theory of Air-Water Interaction in Packed Towers, Tower Height, Cooling Towers
Unit-V	**Agitation And Mixing:** A Basic Stirred Tank Design: The Vessel, Baffles, Draft Tubes, Impeller Types, Impeller Size, Impeller Speed, Impeller Location, Kinds of Impellers, Gas Dispersion: Spargers, Mass Transfer, System Design, Minimum Power, Power Consumption of Gassed Liquid, Superficial Liquid Velocity, Design Procedures In-Line-Blenders and Mixers, Mixing of Powders and Pastes
Text Book: M. V. Joshi, V.V. Mahajan, Design of Process Equipment Design, 3rd Edition, McMillan India.	
Reference 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. J. H. Perry, Chemical Engineer's Hand Book, McGraw-Hill, New Delhi.	

i) Title of course:	Process Modeling and Simulation (PCC-CH402); Credits: 04 (L-3, T-0, P-2)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Apply fundamental laws to formulate mathematical process models.
	2. Develop model equations for steady state processes.
	3. Develop model equations for dynamic processes
	4. Simulate and optimize various chemical engineering processes.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Understand fundamental principles of process modeling and simulation.
	2. Learn to develop mathematical models of phenomena involved in chemical engineering
	3. Solve mathematical models with different simulation tools.
	4. Optimize the operating conditions by simulating mathematical models for process intensification.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Introduction to Process Modeling and Simulation Fundamentals: Uses of Mathematical Models, Scope of coverage, principles of formulation Fundamental laws: Continuity equation, Energy equation and Information flow diagrams, Equations of motion, Transport equations, Equations of state, Phase and Chemical Equilibrium, Chemical kinetics, Classification of process models, Dimensionless modeling approach.
Unit -II	Modeling of Chemical Engineering System –I: Two heated tanks, Batch Reactor, Series of isothermal constant holdup Continuous Stirred Tank Reactor (CSTR), CSTR with variable holdup, Models in reaction kinetics schemes for various reaction schemes: Series parallel, combination, etc.
Unit -III	Gas phase pressurized CSTR, Non-isothermal CSTR, Reactor with mass transfer, Bubble column Reactor, Fluidized Bed Reactor, Packed Bed Reactor, Slurry Reactor, Recycle Reactor, LPG vaporizer, Multi-capacity first order system in series.
Unit -IV	Modeling of Chemical Engineering System-II: Single component vaporizer, Multi-component flash drum, Ideal binary distillation column, Batch distillation with holdup, pH Systems, steady state modeling of Solvent Extraction, two stage extraction, models in heat transfer operation, evaporator, etc.
Unit -V	Computer Simulations: Batch reactor, Gravity flow tank, Three CSTR in series, Non-isothermal CSTR, etc. Binary distillation column, Multi-component distillation column, Variable pressure distillation column, Ternary batch distillation with holdup etc Introduction to various chemical engineering process simulators such Polymath / MATLAB / CHEMCAD /Aspen Plus/ Hysys / Unisim etc.
Text Book: William L. Luyben, "Process Modeling, Simulation An Control For Chemical Engineers", McGraw-Hill Publishing Company	
Reference books:	
1. B. V. Babu, "Process Plant Simulation", Oxford publications. 2. V. G. Jenson, and G. V. Jefree, "Mathematical methods in Chemical Engineering", Academic Press 3. John Ingham, et al., "Chemical Engineering Dynamics-An introduction to modeling & computer simulation", John Willey Publications, 2nd completely revised edition.	
Lab work:	
The following experiments have to be conducted using any commercial software package available like Polymath/MATLAB /CHEMCAD/Aspen Plus/Hysys /Unisim , etc. (Any 08 out	

of 13 listed below).

1. Gravity Flow tank.
2. Three CSTR's in series – open loop.
3. Three CSTR's in series – closed loop.
4. Non-isothermal CSTR.
5. Complex reaction scheme (Batch Reactor)
6. Second order complex batch reactor
7. Series parallel reaction scheme
8. Semi-batch reactor model
9. Complex reaction model
10. Parallel second order reaction scheme
11. Reversible and irreversible 1st order reactions
12. 2nd order series reactions
13. Complex set of series parallel reactions

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

i) Title of course:	Transport Phenomena: Credits: 03 (PCC-CH403); Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Learn the fundamentals of transport phenomena.
	2. Identify transport properties of molecular momentum, energy and mass transport.
	3. Adopt the shell balance approach to transport processes.
	4. Familiarize the equations of change.
	5. Recognize analogies among momentum, heat and mass transfer.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Interpret the chemical and physical transport processes with mechanisms.
	2. Formulate heat, mass and momentum transfer analysis by setting up shell balances for desired profiles of process variables
	3. Develop steady and time dependent solutions along with their limitations.
	4. Apply equations of change to obtain engineering quantities of interest.
	5. Compare the analogies amongst momentum, heat and mass transfer.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Introduction and approach in momentum transfer: Definition of transport properties, their measurement and estimation, flow of Newtonian & Non-Newtonian fluids, development of boundary layer, Shell balance approach for developing momentum balance,
Unit -II	Development of velocity profile: Velocity distribution in laminar and turbulent flow, Flow in some simple cases - Flow over an inclined plane, Flow between two parallel plates, flow between two concentric rotating cylinders, steady flow around a sphere (theory of very slow motion),
Unit -III	Fundamental laws: Equations of Continuity, Euler, Motion and Navier–stokes (Cartesian, cylindrical, and spherical coordinates) in laminar flows and its applications for the calculation of velocity profiles, shear stresses, power, etc. in various engineering applications, dimensional analysis of equation change.
Unit -IV	Introduction and approach in heat transfer: Shell balance approach for developing equations for heat transport, development of thermal boundary layer, Temperature distribution in solids and fluids in laminar flow. Temperature distribution with and without heat generation
Unit -V	Development of temperature profile: Heat conduction with electrical heat source, Heat conduction with a nuclear heat source, Heat conduction with a viscous heat source, Heat conduction with a chemical heat source, Heat conduction with variable thermal conductivity, Forced and free convection, Heat conduction in a cooling fin, etc.
Unit -VI	Development of concentration profile: Shell balance approach for developing equations for mass transport, Concentration distribution in solids and in fluids in laminar flow- Diffusion through stagnant gas film, Diffusion with heterogeneous chemical reaction, Diffusion with homogeneous chemical reaction , Diffusion through Pyrex tube, etc. Analogies between heat, momentum and mass transport. Applications of heat, momentum and mass transport concepts to various disciplines of engineering and technology
Text Book: Bird R.B., Stewart W.E., Lightfoot E.N, "Transport Phenomena", John Wiley & Sons, Singapore, 1960 & 2002.	
Reference books:	

1. Thomson, W.J. "Introduction to Transport Phenomena", Pearson Education Asia, Singapore, 2000.
2. Brodkey R.S. and Hershey H.C, Transport Phenomena: A Unified Approach, McGraw-Hill, New York,1988.
3. Plawsky J.L, "Transport Phenomena Fundamentals", Marcel Dekker, New York, 2001.
4. Slattery J.C., Sagis L., Oh E-S. "Interfacial Transport Phenomena", Springer, New York, 2007.

i) Title of course:	Industrial Organization & Management; (HMC-CH404) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Understand the management process and structure in the industry so that it will help them to work in a better way.
	2. Develop an efficient methodology for industrial management.
	3. Cater the issues related to current industrial amendments.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Study the management concept, its functions and responsibility.
	2. Understand the human resource management in industry.
	3. Understand the store and purchase management.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Management Science: 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
Unit -II	Business Organization: Different forms of organization, their formation and working, Different organization structure-line organization, functional organization, line and staff organization.
Unit -III	Personnel Management: Man power 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.

Unit -IV	Purchase and stores management: 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.
Unit -V	Export and import management: 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.
Unit -VI	Management Laws: Concepts of contract act, offer, and acceptance, types of contracts, Void contract, concept of guarantee and warranty. Introduction of MRTP and FERA.

Text Book:

Industrial Engineering and Management-O. P. Khanna

Reference books:

1. Management for Business and Industry-C.S. George Jr.
2. Principles of management-Knoots and O. Donnell.
3. Business Organization and management-M.C. Shulka.

i) Title of course:	Elective-III: Piping Engineering; (PEC-CH405) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Capable to understand the concepts of the nature of fluid flow.
	2. Ability to analyze Flow of liquid in Pipe.
	3. Should understand the concept of Pipe surface roughness effects.
	4. Get familiar with phenomenon of pipe networking.
	5. Understand the difference between pipes and tubes.
	6. Understand the Apparent Reynolds.
iii) Course objectives:	Students undergoing this course will be able to- ;
	1. To study the basics of Piping Engineering.
	2. Explain concepts related to Piping Engineering..
	3. Use information of what Piping Engineer should know to implement in new situation.
	4. To understand the fundamentals about pipes and tubes
	5. To understand the role, responsibilities of Piping Engineering.

iv) Mapping of course outcomes with programme outcomes

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
CO6	2	1	3	2	-	-	-	-	-	-	-	1

Unit	v) Course Content:
Unit -I	Introduction of Piping Engineering, role, responsibilities of Piping Engineering, Classification of pipes and tubes, IS & BS codes for pipes used in chemical process industries and utilities. Pipes and tubes, difference between pipes and tubes.
Unit -II	Flow of liquid in pipe, Newtonian fluids, the nature of fluid flow, flow over a surface, Pipes for Newtonian and non-Newtonian fluids, sudden expansion, and contraction effects, Pipe surface roughness effects, pipe bends, shear stress in fluid, Shearing characteristics.
Unit -III	Force exerted by flowing fluid on pipe bends. Pressure drop for flow of Newtonian and non-Newtonian fluids through pipes. Resistance to flow and pressure drop, Apparent Reynolds number & shear stress Effect on Reynolds number and apparent Reynolds number.
Unit -IV	Derivation, stress strain, yields. Pipes of circular and non-circular cross section – velocity distribution, average velocity and volumetric rate of flow. derivation, Flow through curved pipes (Variable cross sections). Effect of pipe-fittings on pressure losses.
Unit -V	Flow through annulus, flow between two parallel plates – velocity distribution, average velocity and volumetric rate of flow. Non-Newtonian fluid flow through process pipes, Shear stress, Shear rates behavior, apparent viscosity and its shear dependence, Power law index, Yield Stress in fluids, Time dependent behavior, Thixotropic and rheopetic behavior, mechanical analogues, velocity pressure relationships for fluids, line. Elasticity, viscosity, dilatant, viscoelastic, strain.
Unit -VI	Pipe line design and power losses in compressible fluid flow, Multiphase flow, gas-liquid, solid-fluid, flows in vertical and horizontal pipelines, Lockhart Martinelli relations, Flow pattern regimes. Hardy cross method, rules, process.

Text Book:

Coulson JM and Richardson J.F. – Chemical Engineering – Vo-lI, VI Edition, Butterworth Heinemann, British Library, Publications, Oxford, 1999.

Reference books:

1 Govier, G.W. and Aziz K. – The flow of Complex Mixtures in Pipe – Krieger Publication, Florida, 1982.

2. Green DW and Malony, Perrys – Chemical Engineers Handbook – VII Edition McGraw Hill, Bew York, 1997.

i) Title of course:	Elective-III Optimization Techniques; (PEC-CH406) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Formulate optimization problems
	2. Understand and apply the concept of optimality criteria for various types of optimization problems
	3. Solve various constrained and unconstrained problems in single variable as well as multivariable

	4. Apply the methods of optimization in real life situation.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Introduce the fundamental concepts of Optimization Techniques;
	2. Create awareness of the importance of optimizations in real scenarios
	3. Provide the concepts of various classical and modern methods of constrained and unconstrained problems in both single and multivariable.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Introduction to optimization; Formulation of objective function; Basic concepts-functions, regions, necessary and sufficient conditions for an extremum of an unconstrained function.
Unit -II	One dimensional Search: Scanning and bracketing; Newton, quasi-Newton and secant methods; Region elimination method; Polynomial approximation methods.
Unit -III	Unconstrained multivariable optimization: Direct methods-random searches, grid search, univariate search, simplex method, conjugate search direction and Powell's method; indirect method-gradient and conjugate gradient methods, Newton's method, movement in search direction, secant method.
Unit -IV	Linear programming: Basic concepts in linear programming; Graphical solution; Simplex method; Standard LP from; Obtaining first feasible solution; Sensitivity analysis.
Unit -V	Non-linear programming: Lagrange multiplier method; Quadratic programming; Penalty function and augmented Lagrangian methods; Successive quadratic programming; Optimization of dynamic processes.
Unit -VI	Optimization of staged and discrete processes: Dynamic programming; Integer and mixed integer programming. Nontraditional optimization techniques: Simulated anneling; Genetic algorithms; Differential evolution. Application of optimization in the design of separation process, chemical reactor and large scale process plant.
Text Book: Engineering Optimization Theory & Practice, S. S. Rao,	
Reference books:	
1. Multi-Objective Optimization Using Evolutionary Algorithms K. Deb, 2. Process Plant Simulation, B.V. Babu 3. Optimization of Chemical Processes, T. F. Edgar, D. M. Himmelblau	

i) Title of course:	Elective-III: Computational Fluid Dynamics; (PEC-CH407) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Construct the differential equations for flow phenomena and apply numerical methods for their solution
	2. Use and develop flow simulation software for the most important classes of flows in engineering and science
	3. Critically analyze different mathematical models and computational methods for flow simulations
	4. Undertake flow computations using current best practice for model and method selection, and assessment of the quality of results obtained.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Introduce computational methods to study fluid dynamics
	2. Learn how to formulate and solve computational problems arising in the flow of fluids
	3. Assess the accuracy of numerical solutions by comparing with known solutions of simple test problems and by mesh refinement studies
	4. Use CFD to predict forces on transport systems.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Conservation equations for mass, momentum and energy; Comparison of various numerical techniques for CFD; Review of finite difference and finite element methods; Solution to discretized algebraic equation; Finite volume method for diffusion problems;
Unit -II	Finite-volume method for convection and diffusion problems – pressure velocity coupling; Construction of geometry and discretion using Gambit-Fluent‘s manuals;
Unit -III	Commercial CFD solvers; Turbulence modeling; Implementation of boundary conditions;
Unit -IV	Introduction to multiphase flow; Customizing commercial CFD solver. Case Studies: Benchmarking, validation, Simulation of CFD problems by use of general CFD software, Simulation of coupled heat, mass and momentum transfer problem.
Text Book: An Introduction to Computational Fluid Dynamics: The Finite Volume Method H.K. & Malalasekera W.	

Reference books:
1. Computational Fluid Dynamics: The Basics with Application Anderson, J.D. 2. Computational Methods for Fluid Dynamics Ferziger J.H. and Peric M.

i) Title of course:	Elective-III: Catalytic Science & Engineering; (PEC-CH408) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Apply knowledge of heterogeneous catalytic reactions in industrial applications.
	2. Find out the mechanism and kinetics of heterogeneous catalytic reactions
	3. Prepare required catalyst and carry out characterization of the same
	4. Predict mass and heat transfer effects on heterogeneous catalytic reactions
	5. Design reactors for heterogeneous catalytic reactions.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Impart basics of catalysis
	2. Understand heterogeneous catalytic processes.
	3. Understand reaction kinetics and mechanism of heterogeneous catalytic reactions.
	4. Learn catalytic phenomena with extensions to reactor design.
	5. Know various catalyst preparation and characterization techniques.
	6. Understand the techniques involved in enhancing catalyst activity and life time.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Heterogeneous catalytic processes, types of heterogeneous reactions. Absorption, absorption isotherms, rates of absorption, Physisorption and chemisorptions. Solid catalysis, types of catalysts, catalyst formulations and Preparation methods..
Unit -II	Catalysts Characterization methods: Surface area and pore volume determinations, XRD,

	various Spectroscopic techniques, Temperature programmed reduction & oxidation, Electron microscopy
Unit -III	Testing of catalysts, various types of reactors, activity and selectivity studies. Effect of external transport processes on observed rate of reactions. Effect of internal transport processes: reactions and diffusion in porous catalysts. Mechanism of catalytic reactions, Rates of adsorption, desorption, surface reactions, rate determining steps.
Unit -IV	Kinetic modeling and Parameter estimations, model discriminations. Catalysts promoters, inhibitors, catalyst deactivation, kinetics of catalyst deactivations. Industrial processes involving heterogeneous solid catalysts.
Unit -V	New developments in solid catalysis, monolith catalysts, nanocatalysts, fuel cell catalysts, environmental catalysts, in-situ characterization. Design of catalysts, simulation techniques
***Text Books*:** J. J. Carberry, "Chemical and catalytic reaction Engineering", Dover Publications.	
Reference books:	
1. G. Ertl, H. Knozinger and J. Weitkamp, "Handbook of Heterogeneous Catalysis", Vol 1-5, Wiley - VCH. 2. B. Viswanathan, S. Sivasanker, A.V. Ramaswamy", Catalysis: Principles & Applications" CRC Press. 3. J. M. Smith, "Chemical Engineering Kinetics" McGraw-Hill Book Company. 4. J. M. Thomas and W. J. Thomas, "Principles and Practice of Heterogeneous Catalysis", Wiley-VCH. 5. H. S. Fogler, "Elements of Chemical reaction engineering" Prentice – Hall of India. 6. C. H. Bartholomew and R. J. Farrauto "Fundamentals of Industrial catalytic Processes", Wiley-VCH.	

i) Title of course:	Elective-III: Sustainable Chemical Technology; (PEC-CH409) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Understand the different types of environmental pollution problems and their sustainable solutions
	2. Analyze the principles of sustainability.
	3. Work in the area of sustainability for research and education
	4. Having a broader perspective in thinking for sustainable practices by utilizing the engineering knowledge.
	5. Produce new ideas from sustainable development
iii) Course objectives:	Students undergoing this course will be able to-
	1. Have an increased awareness among students on issues in areas of sustainability
	2. To understand the role of engineering and technology within sustainable development
	3. To know the methods, tools, and incentives for sustainable product-service system development
	4. To understand the fundamentals about Sustainable Chemical Engineering
	5. To establish a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental,

	societal, and economic problems.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Sustainability- need and concept, challenges; Environment acts and protocols, Global
Unit -II	Regional and Local environmental issues Natural resources and their pollution, Carbon credits Zero waste concept ISO 14000, Life Cycle Analysis
Unit -III	Environmental Impact Assessment studies Sustainable habitat, Green buildings, green materials, Energy
Unit -IV	Conventional and renewable sources, Technology and sustainable development,
Unit -V	Sustainable urbanization, Industrial Ecology
Text Book: Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall	
Reference books:	
1. Bradley. A.S; Adebayo, A. O., Maria, P. Engineering applications in sustainable design and development, Cengage learning Environment Impact Assessment Guidelines, Notification of Government of India, 2006 2. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998 3. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System 4. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.	

i) Title of course:	Seminar; (SEM-CH410) Credits:01 (L-0, T-0, P-2)
	Students who have succeeded in this course can-
ii) Course Outcomes:	1. This memorandum provides each student the administrative details and guidance necessary to successfully completion of seminar. 2. This course is intended to enhance students' effectiveness. 3. Topics covered include: fundamentals of chemical engineering, professional development, academic development, personal development and orientation to the field of engineering.
iii) Course objectives:	Students undergoing this course will be able to- 1. Collect literature on a given topic 2. Classify the collected literature into various categories 3. Summarize and write a few paragraph on each paper 4. Compare the information content given in different papers 5. Analyze a particular paper based on principle of Chemical Engineering 6. Write a report based on his / her work
iv) Course content:	Students will be required to prepare a critical review of selected topics in Chemical Engineering and allied subjects and submit in the form of a standard typed report. Typically, the report should contain and will be evaluated based on the following points: (i) Introduction: 2 pages maximum, (ii) Exhaustive review of literature (including figures): 10 – 12 pages: 50% weightage (iii) Critical analysis of the literature and comments on the analysis (including figures): 10 – 12 pages: 50% weight age. The critical analysis of literature should include the following points: are the papers technically correct? Are assumptions reasonable; is the reasoning logical? If you think it is not, specify what you think is incorrect and suggest the correct approach. Are the methods used in the literature appropriate? Are there any internal contradictions or computational errors and are there any loopholes in the observations? If so, please explain. Critical analysis of papers should also contain quantitative comparison of observations, results and conclusion amongst the various papers. Each student will also be required to make an oral presentation of the review. Weight age would be 40% for the presentation and 60% for the report. Additional details and requirements are given to the Students every year by the coordinator of this activity.

Mapping of course outcomes with programme outcomes

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

i) Title of course:	Minor Project; (PRJ-CH411) Credits:04 (L-0, T-0, P-8)
	Students who have succeeded in this course can-
ii) Course Outcomes:	1. Apply basic fundamentals of chemical engineering for execution of process design
	2. Identify needs for further and continuous development in area selected for project work
	3. Apply the relevant knowledge and skills with area of project work
	4. Do critical assessment of own results obtained based on experimental findings.
	5. Analyze a particular paper based on principle of Chemical Engineering
	6. Analysis of economical feasibility bases on detailed project report.
iii) Course objectives:	Students undergoing this course will be able to- ;
	7. Introduce student to Principles of project management for efficient completion of the project in optimum duration with efficient use of available resources.

iv) Mapping of course outcomes with programme outcomes

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

v) Course Content:
Students will be allotted project either individually or in groups. Each project will have one guide from the faculty. Students may be encouraged to choose co-guide from the industry, wherever possible. The aim of the project work is to evaluate the quality and competence developed by the

students implementing theoretical concepts learned, in terms of technical report / presentation. The students may encourage doing Plant Design Project.

In case of Plant Design Project, the report must consist of the following chapters:

1. Introduction (including market report)
2. Process Selection
3. Material and Energy Balance
4. Sizing and detailed design of major equipment/s
5. Thermodynamics and Kinetics
6. Instrumentation & Process Control
7. Plant Layout
8. Waste Treatment & Safety aspects
9. Cost Analysis References Appendices

In case of strictly research or more practical project, the report must consist of the following chapters:

1. Abstract
2. Aim and Objectives
3. Introduction/background
4. Literature Review
5. Methodology
6. Results
7. Discussion
8. Conclusion and recommendations References Appendices

In case of Modeling and Simulation Project, for example "Modeling and Simulation of Trickle Bed Reactor", the report may consist of the following chapters:

1. Introduction
2. Literature Review

Syllabus of course: Semester VIII (Scheme-A)

i) Title of course:	Elective-IV: Nanotechnology; (PEC- CH413) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can
	1. Understand broad areas of nanotechnology.
	2. Synthesize different nanomaterials and perform their characterization.
	3. Apply knowledge in interdisciplinary areas of science and technology
iii) Course objectives:	Students undergoing this course will be able to- 1. Understand basic concepts of nanotechnology 2. Learn different synthesis methods for nano-materials and characterize those using different techniques 3. Study applications of nanotechnology in interdisciplinary areas such as water treatment, nano-biotechnology, chemical engineering, etc.

iv) Mapping of course outcomes with programme outcomes

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

Unit	v) Course Content:
Unit -I	Introduction to nanotechnology and materials, Nanomaterials, How It All Began: Synthesis of carbon buckyballs, List of stable carbon allotropes, extended, fullerenes, metallofullerenes, solid C 60, bucky onions, nanotubes, nanocones, Properties of Individual nanoparticles, Methods of synthesis, Carbon nanostructures.
Unit -II	Synthesis procedures of nanomaterials :Bottom-up vs. top-down , Epitaxial, growth ,Self-assembly, Modeling 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) nanotube synthesis based on Boudoir, reaction Chemical Vapor Deposition (CVD)
Unit -III	Characterizations of nanomaterials: Top down approach Bottom up, approach Optical Microscopy, Electron Microscopy, Secondary electron scattering, back, scattering, Scanning Probe Microscopes, Focused Ion Beam Technique, X-ray imaging, SPM-AFM, STM, Optical Microscopy, Electron Microscopy, Secondary electron scattering, back scattering, Scanning Probe Microscopes, Intrinsic semiconductors, Band gaps, Law of mass action, Mobility of charge carriers Extrinsic semiconductors The p-n junction,

	Ferromagnetism Energy gaps;
Unit -IV	Nano colloids and Chemistry: 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. Applications and Safety, Environment: Waste Water Treatment, Nano-biotechnology: Drug Delivery, Nano clay, Nanocomposites, Surface coatings.
Unit -V	Self-cleaning Materials, Hydrophobic Nanoparticles. Biological nanomaterials. Nano electronics. Nano machines & Nano devices Societal, Health and Environmental Impacts, Commercial Processes for Nanotechnology and Chemical Engineering Applications Nano hydrogel, Photocatalytic reactors, Nano clay Synthesis, Polymer nanocomposite, Introduction to industries which produces commercial nonmaterial'
Text Book: Introduction to Nanoscience, (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: 978-142004805	
Reference books:	
1. Introduction to Nanoscience and Nanotechnology, Chris Binns, 2010, Wiley, ISBN: 978-0471776475 2. Introduction to Nanoscience, Stuart Lindsay, 2009, Oxford University Press	

i) Title of course:	Elective-IV: Refining science and engineering ; (PEC- CH414) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Develop knowledge of different refining processes
	2. Develop knowledge of safety and pollution control in the refining industries.
	3. To find the suitable refining technology for maximizing the gasoline yield
iii) Course objectives:	Students undergoing this course will be able to-
	1. Various extraction techniques for the production of oil and gas to meet energy needs.
	2. Refining operations of crude oil for a wide spectrum of useful products.
	3. Production processes for various petroleum products from refined crude oil.

iv) Mapping of course outcomes with programme outcomes

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

Unit	v) Course Content:
Unit -I	History of petroleum, types and ages of rocks, Theories and origin and accumulation of oil and gas, Kerogen composition, classification, isolation, Properties of petroleum and gas in rocks, porosity, permeability, connate water, electrical resistivity, compressibility of rocks, phase behavior, shrinkage, viscosity, compressibility, permeability, mobility, interfacial tension, wetting capillary pressure and forces of oil and flows
Unit -II	Methods of surface and subsurface exploration (geological, geophysical and geochemical) cable tool, rotary and turbo drilling, drilling of wells (vertical, deviated and horizontal). Drilling, fluids, composition and functions, rates, coring, cementing, acidization, fracturing, completion and testing of wells, logging, methods of primary recovery. Well testing and control, free flow and gas lifting, mechanical pumping, work over jobs, treatment of water for injection, enhanced oil recovery, secondary and tertiary.
Unit -III	Separation of Oil and Gas, gathering, stabilization, dehydration, desalting, sorting and mixing, transportation and storage of oil and gas, metering systems, group gathering stations and tank firms. Elementary concept of fractionation – Distillation theory (atmospheric pressure, reduced pressure, azeotropic and extractive) solvent treatment, asphaltene separation and fractionation.
Unit -IV	Absorption, chemical methods like sulphuric acid treatment, molecular complex formation, Extraction and use of data. Composition of petroleum, natural gas, major petroleum fractions and products (refinery gases, gasoline, naphtha, kerosene, diesel, fuel oil, lubricating oil, other oil products, waxes, asphalt, coke, acid sludge) Hydrocarbons and non-hydrocarbons present (Type, name, structure, role) chemical aspects of origin of petroleum and natural gas.
Unit -V	. Classification and description of various crudes. General methods of classification and correlations. N-d-M ring analysis method, comparison of structural group analysis by spectroscopic and physical property methods. MW determination, correlation method for structure of solid saturated hydrocarbons.
Text Book: Petroleum Refining Engineering : W L Nelson	
Reference books:	
1. An introduction to Physics and Chemistry of Petroleum : R R F Kinghorn 2. Composition and properties of Petroleum : H J Neumann, B P Lahme and B Severin 3. Modern Petroleum Technology : G D Hobson and W Pohl 4. Chemical Technology of Petroleum : W A Gruce and Stevens 5. The Chemistry and Technology of Petroleum : James G Speight 6. Petroleum refining, Technology and Economics : J H Gary and G E Handwork.	

i) Title of course:	Elective-IV: Safety & Risk Analysis; (PEC- CH415) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Identify, Explain and Handle Different safety principles.

	2. Identify Different Hazards And their Fire protection agency's
	3. Analyze various health hazards & apply Hazards Safety in operations and processes
	4. Identify Safety aspects of reactive chemicals
	5. Compose and perform accident analysis from accident documentation to analytical explanation of possible causation processes, and document into an accident report
	6. Explain the legal and specified requirements for conducting continuous risk assessments.
iii) Course objectives:	Students undergoing this course will be able to- 1. To understand Basics of Industrial Safety Management. 2. Know various aspects of Chemical plant safety 3. Ought to know the various aspects of Industrial accidents and Fire safety 4. Know Hazard identification techniques 5. Various aspect of industrial hygiene and Occupational Health hazards, Safety legislation in Chemical industries 6. Be aware of the legal requirements governing risk assessments.

iv) Mapping of course outcomes with programme outcomes

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
CO6	2	3	2	2	-	1	-	-	-	-	-	1

Unit	**v) Course Content:**
Unit -I	Industrial Safety Management:- Importance of Safety consciousness in Indian Chemical Industries – Development of Industrial Health and Safety, Safety Organization –Polices-Culture - Planning- Promotion – Inspection –Rules- Responsibility – Supervision, Safety Committee – role of safety functionaries, Elements of work place Safety Program, Economic and Social Benefits from Safety Program- Effective Safety Education and Training – Communication at various levels of production and operation, Safety slogans Chemical Plant
Unit -II	Safety:- Chemical process Industries - Sitting and Layout of a Chemical plant, Safety in transportation, storage and handling of hazardous chemicals, Chemical process hazards and their control - First degree and second degree hazards. Lines of defense - High pressure - High temperature operations – Case studies,
Unit -III	Emergency preparation: On-site and Offsite , Safety aspects of maintenance in chemical

	plant -Effective steps to implement safety proceduresPeriodic Advice and checking to follow safety procedures and rules- Safe guarding of Machines – Ergonomics -Proper selection and replacement of handling equipment –Safe handling and operation of materials and machineries Accident And Their Prevention:- Definitions, H.W.Henrich, Frank bird & Multiple Causation theories of accident occurrences, Classification, Causes, Costs -Industrial accidents, Principles of Accident prevention, Accident prevention technique – Plant and Chemical job safety analysis, Accident proneness-vocational guidance, Safety performance measurement tools - FR. SR, (FSI), Safe-T-Score, Accident rate per 1000 workers, Disabling injury index, Accident Compensation Statutes, Accident Investigation reporting and Analysis - Case studies.
Unit -IV	Conditions -Fire triangle Classification of fires, Common causes of industrial fires, Fire protection systems prevention Case studies, Safety in Explosive Hazard Identification Techniques:- Safety Appraisal - Risk Assessment -Hazard identification techniques with examples such as FMEA, CMA, Fault Tree Analysis, Preliminary Hazard Analysis (PHA), Hazard and operability (HAZOP) study, Quantitative risk analysis-Out line of methodology, Consequences analysis (Calculation of release rates of liquids under ambient pressure and liquids under pressure, Calculation of dispersion of released gases and vapors and platting of equal concentration contours), Dow (Index) Fire and Explosion Index System of Risk Analysis, Safety Audit.
Unit -V	Industrial Hygiene And Occupational Health Hazards:- Concepts - Industrial and Occupational health hazards, Housekeeping, human factors and error, stress at work, Personnel protective equipments, Role of trade unions in Industrial safety and health. Safety And Law:- Introduction to ILO, Safety legislation in India, Factories act 1948, Employees welfare and legislation, Provisions relating to safety , health & environment in other important legislations - Indian boilers act and regulations, Indian electricity act and rules, Indian explosives act and rules, Mines act, Petroleum act and rules. Environmental protection act.
Text Book: Daniel A. Crowl and Joseph F. Louvar, "Chemical Process Safety: Fundamentals with Applications" Prentice Hall International Sereis	
Reference books:	
1.Greene R. "Safe and Efficient Plant Operation and Maintenance", McGraw Hill Book Co., New York. 2. Dixit, "Safety Evaluation of Environmental Chemicals", PHI. 3. Dekkar Marcel, "Safety Management and Practices for Hazardous Units", McGraw Hill Book Co., New York, 1995 4. Saxena, "Safety and Good House Keeping", National Productivity Council, New Delhi (1976) 5. Wells G.L., "Safety in Process Plant Design", George Godwin Ltd., (1980).	

i) Title of course:	Elective-IV: Polymer Processing; (PEC-CH416) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	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:	Students undergoing this course will be able to-
	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) Mapping of course outcomes with Programme outcomes

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

Unit	**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. 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..
Unit -II	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.
Unit -III	Non isothermal aspects - Temperature effect on rheological properties, Crystallization, Morphology & Orientation, plastic memory, Molecular weight effects on processing and properties.
Unit -IV	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 -V	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:	Elective –IV: Green Chemistry ; (PEC- CH417) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Explain the basics of green chemistry in terms of 12 principles
	2. Develop Green synthesis methods and eco-friendly products
	3. Design and modify the conventional synthesis routes to greener synthesis routes to improve industrial processes and to produce important products
iii) Course objectives:	Students undergoing this course will be able to-
	1. Introduce the 12 principles of green chemistry as well as the tools of green chemistry including the use of alternative feed stocks or starting materials, reagents, solvents, target molecules, and catalysts.
	2. Understand the necessity and viability of the methods of green chemistry to the chemical sciences and related disciplines.
	3. Demonstrate how to evaluate a reaction or process and determine "greener" alternatives.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Principles & Concept Of Green Chemistry:- Introduction –Concept and Principles-development of Green Chemistry- Atom economy reactions –rearrangement reactions, addition reactions- atom uneconomic-sublimation-elimination-Wittig reactions-toxicity measures- Need of Green Chemistry in our day to day life. Green tribunal act 2001.
Unit -II	Measuring And Controlling Environmental Performance :- Importance of measurement – lactic acid production-safer Gasoline – introduction to life cycle assessment-four stages of

	Life Cycle Assessment (LCA) –Carbon foot printing-green process Matrics-eco labels - Integrated Pollution and Prevention and Control(IPPC)-REACH (Registration, Evaluation, Authorization of Chemicals)
Unit -III	Emerging Green Technology And Alternative Energy Sources:- Design for Energy efficiencyPhotochemical reactions- Advantages-Challenge faced by hoto-chemical process. Microwave technology on Chemistry- Microwave heating –Microwave assisted reactions-Sono chemistry and Green Chemistry –Electrochemical Synthesis-Examples of Electrochemical synthesis.
Unit -IV	Renewable Resources:- Biomass –Renewable energy – Fossil fuels-Energy from Biomass-Solar Power- Other forms of renewable energy-Fuel Cells-Alternative economics-Syngas economyhydrogen economy-Bio refinery chemicals from fatty acids-Polymer from Renewable Resources – Some other natural chemical resources.
Unit -V	Industrial Case Studies:- Methyl Methacrylate (MMA)-Greening of Acetic acid manufacture-Vitamin C-Leather manufacture –Types of Leather –Difference between Hide and Skin-Tanning –Reverse tanning –Vegetable tanning –Chrome tanning-Fat liquoring –Dyeing –Application-PolyethyleneZiegler Natta Catalysis-Metallocene Catalysis-Eco friendly Pesticides-Insecticides

Text Book:

1.Mike Lancaster , Green Chemistry and Introductory text, II Edition

2. P.T. Anastas and J.C Warner, Green Chemistry theory and Practice, Oxford University press, Oxford (1988)

Reference books:

1. P. Tundoet. al., Green Chemistry, Wiley –Blackwell, London (2007).
2. Protti D. Dondi et.al. ,Green Chemistry
3. T.E Graedel, Streamlined Life cycle Assessment, Prentice Hall, New Jersey (1998).
4. V.K. Ahluwalia, Methods and Reagents of Green Chemistry: An Introduction by Green Chemistry

i) Title of course:	Elective-V: Waste Water Treatment; (OEC-CH418) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Understand the water standards and disposal norms
	2. Analyze waste water samples for several parameters.
	3. Utilize various unit operations for waste water treatment.
	4. Designing of waste water treatment plant.
	5. Treat waste water with advanced processes
iii) Course objectives:	Students undergoing this course will be able to-
	1. Learn water quality parameters, policies and norms for waste water
	2. Train the students in waste water management techniques.
	3. Teach the processes for transformation of waste water in potable water
	4. Impart the knowledge of waste water analysis techniques.
	5. Understand the designing of industrial waste water treatment equipment's

iv) Mapping of course outcomes with programme outcomes

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

Unit	v) Course Content:
Unit –I	Water Pollutants, Effects, Monitoring and Quality standards: Pollution of water and soil, effect of pollutants on environment and health, monitoring water pollution, water pollution laws and minimum national standards, monitoring, compliance with standards, Latest norms for effluent treatment
Unit –II	Water Pollution Sources, Analysis and Methods of control: Water pollution sources and classification of water pollutants – Wastewater sampling and analysis. Treatment of water pollution: BOD, COD of wastewater and its reduction – Fundamentals of Anaerobic digestion and Aerobic digestion.
Unit –III	Wastewater Treatment Plant Design: Physical unit operations: Screening, Flow equalization, sedimentation etc., Chemical Unit Processes: chemical precipitation, disinfection, colour removal by adsorption Biological unit processes: Aerobic suspended – growth treatment processes, aerobic attached growth treatment processes, anaerobic suspended – growth treatment processes, anaerobic attached-growth treatment processes.
Unit –IV	Advanced Wastewater and Water Treatment: Carbon adsorption – Ion exchange – Membrane processes – Nutrient (nitrogen and phosphorus) removal – Design of plant for treatment and disposal of sludge
Text Book: C.S. Rao, "Environmental Pollution Control Engineering", Wiley 2nd Edition, New Age International Publishers, 2006. 1994	
Reference books:	
1. S.P. Mahajan, "Pollution Control in Process Industries", Tata McGraw Hill, New Delhi, 1985 2. Sincero and G.A. Sincero, Environmental Engineering: A Design Approach Prentice Hall of India pvt Ltd, N.Delhi.1996 3. Tchbanoglous and F.L. Burton, Metcalf and Eddy's Wastewater Treatment-Disposal And Reuse (Third Ed.), TMH publishing Co Ltd, N. Delhi. (1996)	

i) Title of course:	Elective-V: Energy Management ; (OEC- CH419) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Explain the principles and techniques used in energy conservation

	and management
	2. Know the techniques of cogeneration and waste heat recovery in chemical processes.
	3. Perform energy auditing and its economic analysis.
	4. Evaluate the performance of industrial boilers, furnaces etc. by direct and indirect methods
iii) Course objectives:	Students undergoing this course will be able to-
	1. Describe the general aspects of energy management.
	2. Understand the principles and techniques used in energy conservation.
	3. Exercise the methodology of energy auditing and its economics.
	4. Impart the concept of energy cogeneration and waste heat recovery.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**v) Course Content:**
Unit -I	General aspects of energy management: Current energy scenario-India and world, current energy consumption pattern in global and Indian industry,
Unit -II	Principles of energy management, energy security and reliability, energy and environment, Concept of energy conservation, Energy Conservation Act of India (2001),
Unit -III	Energy efficiency in thermal utilities: Thermodynamic energy indices & Bureau, Indian Boiler Act (1923) Boiler-efficiency testing, excess air control, Steam distribution and use, steam traps, condensate recovery, flash steam utilization, heat pipes, heat integration and networking.
Unit -IV	Cogeneration and waste heat recovery: Waste heat recovery, Need, applications, advantages, classification, of cogeneration. Waste heat recovery classification and applications, Potential for waste heat recovery in industry.
Unit -V	Energy auditing: Methodology, analysis of past data, measurements of various parameters, portable and on line instruments.
Unit -VI	Energy economics: Payback period, Rate of Return, life cycle costing. Concept of comprehensive Energy Conservation and Planning.
Text Book:	
1. Vijay Navale & Mahesh Nayvale," Energy Audit & Management",Tech Easy Publication Pune, 2008.	
2. Murphy W.R., McKay G.A, "Energy Management", Murphy Butterworth-Heinemann Ltd., 2001.	
Reference books:	
1 Turner W.C,"Energy Management Handbook", Fairmont Press, Lilburn, Georgia, 1993.	
2. Energy Conservation Handbook, C Douglas, McGraw Hill Publications.	

i) Title of course:	Elective-V: Renewable Energy Resources; (OEC-CH420) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Understand the techniques to exploit the available renewable energy resources such as solar, biofuels, wind power, tidal and geothermal effectively.
	2. Know about the exploration of nonconventional energy resources and their effective tapping technologies.
	3. Understand the effective utilization of available renewable energy resources
	4. Acquire the knowledge of modern energy conversion technologies
iii) Course objectives:	Students undergoing this course will be able to-
	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 application and uses of above energy sources in various industries.
	4. Describe the principles and techniques used in energy conservation and management.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**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. Ocean Thermal Energy -: Principles of ocean thermal energy conversion (OTEC) analysis and sizing of heat exchangers for OTEC. Principle of utilization and its limitations, description of few systems.
Unit -V	Other Non-conventional Energy Sources, fluidized bed combustion, heat from waste and other sources. Energy Conservation: Principles of energy conservation.
Unit -VI	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: Kothari D.P., "Renewable Energy Sources and Emerging Technologies",PHI,2008	
Reference books:	
1. Khan B.H., "Non-Conventional Energy Sources",2nd edition, McGraw-Hill,2009 2. Solanki C.S., "Renewable Energy Technologies",PHI,2009 3. Rai G.D, "Non-Conventional Energy Sources", Khanna Publishers, Delhi. 4. Twiddle J., Weir T., "Renewable Energy Resources", Cambridge University Press, 1986	

i) Title of course:	Elective-V: Food Technology; (PEC- CH421) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Understand food preservation processes.
	2. Use and develop flow of post harvesting operations.
	3. Analyze different food processes.
	4. Design, develop and apply the knowledge to food process operations.
	5. Implement & develop post harvesting processing operation.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Introduce food preservation processes.
	2. Understand harvesting processes.
	3. Learn & implement post processing operations.

iv) Mapping of course outcomes with Programme outcomes

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

Unit	**v) Course Content:**
Unit -I	Introduction and Basic Principles: Importance of food Industry in India, Current status of various food products from cereals, dairy, edible oil, fruits, vegetables and beverages. Physical, chemical, biological, nutritional, sensory characteristics of food.
Unit -II	Post Harvesting operations and storage: Storage of solid foods, Cleaning (wet and dry), sorting by shape, size, color, weight, grading and peeling, Equipment for storage of solids, bins, silos, controlled atmosphere storage for food grains and vegetables and fruits.
Unit -III	Principals involved in degradation and prevention Treatment of milk before storage, effect of pasteurization, heat sterilization, In-container sterilization, storage of oils, filtration, free fatty acids removal, foots and other impurities.
Unit -IV	Processing of fruits for manufacture of Jams, Jellies, operations and equipment's involved. Manufacture of Pickles, Squashes, and beverages, preservatives used in food processing.
Unit -V	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 Post Processing operations: Coating or enrobing operations, equipment and applications,
Unit -VI	Theory of food packaging, types of packaging materials and packaging operations, filing and sealing of rigid and semi-rigid containers. Materials for handling the food items. Temper evident containers.
Text Book:	
1.Fellows P., Ellis H., 1990 – Food Processing Technology Principles and Practice –New York	
2. Considine D. M., Food and Food Production Encyclopedia, VNR New York 1982.	
Reference books:	
1 Matz S. A. : Bakery Technology & Engineering, AVI Publishing, 1960.	
2. Shapton & Shapton, Safe Processing of Foods.	
3. Weiser, Mountney, Gould, Practical Food Microbiology and Technology.	
4. Charm S. E. Fundamentals of food Engineering, AVI, 1963.	
5. Hall, Farral, Rippen, Encyclopedia of food Engineering, AVI, 1970. 6. Mirajkar M, Menon- Food Science and Processing Technology Vol I & II New Delhi, Kanishka Publishers.	

i) Title of course:	Elective–V: Solid Waste Management; (OEC-CH422) Credits: 03 (L-3, T-0, P-0)

ii) Course Outcomes:	Students who have succeeded in this course can-
	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:	Students undergoing this course will be able to-
	1. Explain concepts related to solid wastes
	2. Know different storage techniques for solid waste, its impact on human health and environment
	3. Understand the fundamentals about collection and transfer
	4. Learn the efficient management of solid wastes.

iv) Mapping of course outcomes with programme outcomes

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

Unit	**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; Effects of improper disposal of solid Wastes - public health effects. options under Indian conditions – Critical Evaluation of Options Collection and transfer Methods of Collection - types of vehicles - Manpower requirement - collection routes; transfer Stations - selection of location, operation and maintenance;
Unit -II	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 -
Unit -III	options under Indian conditions Off-site processing Processing techniques and Equipment; Resource recovery from solid wastes - composting, Incineration, Pyrolysis - options under Indian conditions Disposal Dumping of solid waste;
Unit -IV	sanitary landfills - site selection, design and operation of sanitary landfills - Leachate collection and treatment
Text Book: 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
Reference books:
1.Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2000 2. R.E.Landreth and P.A.Rebers, Municipal Solid Wastes - problems and Solutions, Lewis Publishers, 1997 3. Bhide A.D. and Sundaresan, B.B., Solid Waste Management in Developing Countries, INSDOC, 1993.

i) Title of course:	Elective –V: Green Process Engineering; (OEC- CH423) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Explicate the importance of green technology in sustainable development Understand environment laws, carbon credits, ISO 14000 series
	2. Understand the issues and ethics of responsible, safe design
	3. Apply appropriate technology to match a green engineering problem
	4. Understand pollution prevention planning and environment friendly design
iii) Course objectives:	Students undergoing this course will be able to-
	1. Acquire fundamental understanding of basic chemistry and technology behind Green Process Engineering.
	2. Get acquainted with the development of latest technologies and methodologies for environmentally benign processes currently practiced in various industrial sectors
	3. Identify the tools of green technology and zero waste systems.
	4. Understand environmental laws , carbon credit and life cycle assessment methods and tools
	5. Acquire methods for pollution prevention and learn to design for environment

iv) Mapping of course outcomes with programme outcomes

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

Unit	v) Course Content:
Unit -I	Introduction to Green Technology:- Green chemistry and technology for sustainable development, Waste and its minimization, Green political movement, roles and responsibilities of chemical engineers, Twelve principles of green engineering, carbon credits, environmental management system standards- ISO 14000 series.
Unit -II	Green Chemistry and Synthesis :- Green chemistry, Green chemistry methodologies, feed stocks, solvents, synthesis pathways, Functional group approaches to green chemistry, Waste treatment/recycle, Synthetic efficiency, Green chemistry metrics, individual reactions analysis, Atom economy, E-factor and reaction mass efficiency, material efficiency and synthetic elegance ranking, Quantitative/Optimization based frameworks for the design of green chemical synthesis pathways, Green chemistry expert system, case studies.
Unit -III	Evaluation of Environmental Performance During Process Synthesis:- Introduction, Tier-1Environmental performance tools: Economic and environmental criteria, Threshold Limit Values (TLVs), Permissible Exposure Limits (PELs), and Recommended Exposure Limits (RELs), Evaluating alternative synthetic pathways, Tier-2Environmental performance tools: environmental release assessment, Release quantification methods, modeled release estimates, release characterization and documentation, Assessing environmental performance Catalysis for Green Technology:- Role of catalysis, Catalysis and sustainable green chemistry, Heterogeneous catalysis, Solid acids, Solid base catalysis ,Template silica, Polymer supported reagents, Catalysis in novel reaction media, Homogeneous catalysis, Phase transfer catalysis, Biocatalysis, Photocatalysis, Process integration and cascade catalysis
Unit -IV	Flow sheet Analysis For Pollution Prevention:- Pollution prevention planning, Structure of the pollution prevention process, Pollution prevention in material selection for unit operations, Pollution prevention for chemical reactors, separation devices, Storage tanks and fugitive sources, Integrating risk assessment with process design, Process energy integration, Process mass integration, Case study of process flow sheet.
Unit -V	Risk Hazard Minimization:- Overview of risk assessment concepts, Hazard and Exposure assessment, Risk characterization, Design for degradation, Real-time analysis for pollution prevention, inherently safer design for accident prevention, Process safety and thermal hazards, Process control using real-time analysis. Process intensification, Life-Cycle Assessment.

Text Book:

1 Anastas, P.; Warner, J., "Green Chemistry: Theory and Practice", Oxford University Press, London, 1998.

2. David Allen, D and Shonnard, D., "Green engineering: Environmentally conscious design of chemical processes": Prentice-Hall, New Jersey, 2002

3. Albert S. Matlack, "Introduction to Green Chemistry" Marcel Dekker, Inc., New York, 2001

Reference books:

1.Boyle, Godfrey, Bob Everett, Janet Ramage, "Energy Systems and Sustainability: Power for a Sustainable Future", Oxford University Press, 2004

2. Paul L. Bishop, Pollution Prevention: Fundamentals and Practice, McGraw Hill, 2000.

3. Zimmerman, J.B.; Anastas, P.T. "The 12 Principles of Green Engineering as a foundation for

4. Sustainability" in Sustainability Science and Engineering: Principles. Ed. Martin Abraham, Elsevier Science, 2005.

i) Title of course:	Elective –V: Big Data Analytics; (OEC-**4**) Credits: 03 (L-3, T-0, P-0)
ii) Course Outcomes:	Students who have succeeded in this course can-
	1. Identify Big Data and its Business Implications.
	2. List the components of Hadoop and Hadoop Eco-System.
	3. Access and Process the Data on Distributed File System.
	4. Manage Job Execution in Hadoop Environment.
	5. Develop Big Data Solutions using Hadoop Eco System.
iii) Course objectives:	Students undergoing this course will be able to-
	1. Understand the Big Data Platform and its Use cases
	2. Provide an overview of Apache Hadoop
	3. Provide HDFS Concepts and Interfacing with HDFS
	4. Understand Map Reduce Jobs
	5. Provide hands on Hodoop Eco System
	6. Apply analytics on Structured, Unstructured Data.
	7. Exposure to Data Analytics with R.

iv) Mapping of course outcomes with programme outcomes

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

Unit	v) Course Content:
Unit –I	Introduction to Big Data and Hadoop: Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere Big Insights and Big Sheets
Unit –II	HDFS(Hadoop Distributed File System) The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.
Unit –III	Map Reduce Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features

Unit –IV	Hadoop Eco System Pig: Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators. Hive: Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions. Hbase: Hbasics, Concepts, Clients, Example, Hbase Versus RDBMS. Big SQL : Introduction
Unit –V	Data Analytics with R Machine Learning: Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with BigR.
Text Book: Tom White "Hadoop: The Definitive Guide" Third Edit on, O'reily Media, 2012.	
Reference books:	
Seema Acharya, Subhasini Chellappan, "Big Data Analytics" Wiley 2015.	

For Scheme A:

i) Title of course:	Major project; (PRJ–CH425); Credits 8 (L-0, T-0, P-16)
	Students who have succeeded in this course can-
ii) Course Outcomes:	1. To teach our students to analyze and design chemical processes that span molecular to macroscopic scales. To this end, objectives of the Chemical Engineering Undergraduate program are to provide students
	2. with a solid foundation in basic scientific and engineering principles, while allowing specialization in applied chemistry, environmental and biochemical/biomedical engineering, process control and applied mathematics
	3. with relevant experience using laboratory experiments and expertise using statistical tools for analyzing process data and designing experiments aimed at improving process operation and product quality
	4. with up-to-date computer software tools for chemical process simulation, analysis, design and control
	5. with an appreciation of the importance of economic, safety and environmental objectives in chemical process design optimization and control and that our graduates have the required skills to accomplish these objectives
	6. with the required design skills, engineering knowledge, communication skills, and exposure to problem-based learning and team-work to function as capable chemical engineers in industry with preparation for graduate studies
iii) Course objectives:	Students undergoing this course will be able to-
	Introduce student to Principles of project management for efficient completion of the project in optimum duration with efficient use of available resources.

iv) Mapping of course outcomes with programme outcomes

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

v) Course Content:
This is the continuation of work started under course No. CH427 Project Work (Stage I). Every student will have to submit a detailed report (3 copies) of the Project Work as per the standard format prescribed by the department within the deadline announced by the Department. The students will make a PowerPoint presentation of their Project Work is for a panel of Examiners comprising of guide, internal examiner and external examiner. The examiners panel will assess the performance of the students considering their quality of work and presentation skills.

For Scheme B:

i) Title of course:	Major project; (PRJ–CH426)– Credits 14 (L-0, T-0, P-28)
	Students who have succeeded in this course can-
ii) Course Outcomes:	1. To teach our students to analyze and design chemical processes that span molecular to macroscopic scales. To this end, objectives of the Chemical Engineering Undergraduate program are to provide students
	2. with a solid foundation in basic scientific and engineering principles, while allowing specialization in applied chemistry, environmental and biochemical/biomedical engineering, process control and applied mathematics
	3. with relevant experience using laboratory experiments and expertise using statistical tools for analyzing process data and designing experiments aimed at improving process operation and product quality
	4. with up-to-date computer software tools for chemical process simulation, analysis, design and control
	5. with an appreciation of the importance of economic, safety and environmental objectives in chemical process design optimization and control and that our graduates have the required skills to accomplish these objectives

	6. with the required design skills, engineering knowledge, communication skills, and exposure to problem-based learning and team-work to function as capable chemical engineers in industry
	7. with preparation for graduate studies
iii) Course objectives:	Students undergoing this course will be able to-
	Introduce student to Principles of project management for efficient completion of the project in optimum duration with efficient use of available resources.

iv) Mapping of course outcomes with programme outcomes

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

v) Course Content:
This is the continuation of work started under course No. CH427 Project Work (Stage I). Every student will have to submit a detailed report (3 copies) of the Project Work as per the standard format prescribed by the department within the deadline announced by the Department. The students will make a PowerPoint presentation of their Project Work is for a panel of Examiners comprising of guide, internal examiner and external examiner. The examiners panel will assess the performance of the students considering their quality of work and presentation skills.