SIR CHHOTU RAM INSTITUTE OF ENGINEERING & TECHNOLOGY
Approved by AICTE
C.C.S. University Campus, Meerut

Sir Chhotu Ram Institute of Engineering and Technology
Chaudhary Charan Singh University Meerut

COURSE /PROGRAM OBJECTIVE & OUTCOME

Session : 2017-2018

B.TECH
(CHEMICAL ENGINEERING)

Sir Chhotu Ram Institute of Engineering and Technology
C.C.S University Campus
Meerut Uttar Pradesh 250001

DEPARTMENT VISSION AND MISSION

VISSION	MISSION
To be a department of global renown with advancing contributions in chemical engineering to society through excellence in education, research and social responsibility	The Department of Chemical Engineering is committed to (1) Provide outstanding education thereby producing engineers empowered with excellent technical and leadership skills, integrity and social responsibility (2) Create novel and sustainable solutions to serve public interests and to address global challenges in key areas of Chemical Engineering

PROGRAM EDUCATIONAL OBJECTIVES (PEO's)

Through the integration of knowledge and skills acquired through the academic courses, extracurricular experiences, and faculty expertise, the graduates of the Chemical Engineering Program will

- Become successful whether in their chemical engineering profession, in advanced studies in engineering or science or in other complementary disciplines.
- Assume leadership roles in industry, business and/or their communities.
- Contribute to the economic environment of their communities.
- Further develop career skills through life-long learning

PROGRAM OUTCOMES

The student will have

- ✓ An ability to apply knowledge of mathematics, science and chemical engineering in the design and operation of chemical processes
- ✓ An ability to identify, formulate and solve complex problems in the various domains of chemical engineering such as fluid mechanics, heat transfer, mass transfer, mechanical operations and transport phenomena
- ✓ An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability
- ✓ An ability to design and conduct experiments, as well as to analyze and interpret data
- ✓ An ability to use the techniques, skills, and modern engineering tools necessary for chemical engineering practice
- ✓ A knowledge of contemporary issues
- ✓ The broad education necessary to understand the impact of chemical engineering solutions in a global, economic, environmental and societal context
- ✓ An understanding of professional and ethical responsibility
- ✓ An ability to work individually and as a member of a team
- ✓ An ability to communicate effectively
- ✓ An ability to function on multidisciplinary teams
- ✓ A recognition of the need, and an ability to engage in life-long learning

B.TECH II YEAR III SEMESTER
CHEMICAL ENGINEERING

S. No.	Subject Code	Subject Name	L-T-P	ESE Marks	Sessional		Total	Credit
					CT	TA		
1.		Polymer Science & Technology	3-1-0	70	20	10	100	4
2.		Universal Human Values & Professional Ethics	3-0-0	70	20	10	100	3
3.		Environmental Pollution Monitoring & Control	3-0-0	70	20	10	100	3
4.		Mechanical Operation	3-0-0	70	20	10	100	3
5.		Material & Energy Balance	3-1-0	70	20	10	100	4
6.		Chemical Engg. Fluid Mechanics	3-0-0	70	20	10	100	3
7.		Environmental Pollution Monitoring & Control Lab	0-0-2	50	30	20	100	1
8.		Mechanical Operation Lab	0-0-2	50	30	20	100	1
9.		Computer Application Lab	0-0-2	50	30	20	100	1
10.		Chemical Engg. Fluid Mechanics Lab	0-0-2	50	30	20	100	1
11.		Elements of Mechanical Engineering*	3-1-0	70	20	10	100*	--
12.		Computer Aided Engineering Graphics*	0-0-3	50	30	20	100*	--
Total							1000	24

CT: Class Test TA: Teacher Assessment L/T/P: Lecture/ Tutorial/ Practical

***B.Tech. IInd year lateral entry students belonging to B.Sc. Stream, shall clear the subjects RCE151/RCE251 and RME101/201 of the first year Engineering Programme along with the second year subjects.**

Science Based Open Elective:

NOE031 Introduction to Soft Computing (Neural Network, Fuzzy Logic and Genetic Algorithm
NOE032 Nano Sciences
NOE033 Laser Systems and Applications
NOE034 Space Sciences
NOE035 Polymer Science & Technology
NOE036 Nuclear Science
NOE037 Material Science
NOE038 Discrete Mathematics
NOE039 Applied Linear Algebra

*Human values & Professional Ethics /Cyber Security will be offered as a compulsory audit course for which passing marks are 30% in End SemesterExamination and 40% in aggregate

B.TECH II YEAR IV SEMESTER
CHEMICAL ENGINEERING

S. No.	Subject Code	Subject Name	L-T-P	ESE Marks	Sessional		Total	Credit
					CT	TA		
1.		Mathematics-III	3-1-0	70	20	10	100	4
2.		Environment & Ecology	3-0-0	70	20	10	100	3
3.		Process Instrumentation	3-0-0	70	20	10	100	3
4.		Mass Transfer-I	3-0-0	70	20	10	100	3
5.		Chemical Engineering Thermodynamics	3-1-0	70	20	10	100	4
6.		Heat Transfer	3-0-0	70	20	10	100	3
7.		Mass Transfer-I Lab	0-0-2	50	30	20	100	1
8.		Chemical Process Instrumentation Lab	0-0-2	50	30	20	100	1
9.		Seminar	0-0-2			100	100	1
10.		Heat Transfer Lab	0-0-2	50	30	20	100	1
11.		Elements of Mechanical Engineering*	3-1-0	70	20	10	100*	--
12.		Computer Aided Engineering Graphics*	0-0-3	50	30	20	100*	--
Total							1000	24

CT: Class Test **TA**: Teacher Assessment **L/T/P**: Lecture/ Tutorial/ Practical

***B.Tech. II[nd] year lateral entry students belonging to B.Sc. Stream, shall clear the subjects RCE151/RCE251 and RME101/201 of the first year Engineering**

Programme along withthe second year subjects.

B.TECH III YEAR V SEMESTER
CHEMICAL ENGINEERING

S. No.	Course Code	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
THEORY SUBJECTS											
1		Mass Transfer II	3	1	0	30	20	50	100	150	4
2		Transport Phenomena	3	1	0	30	20	50	100	150	4
3		Chemical Reaction Engineering I	3	1	0	30	20	50	100	150	4
4		Thermodynamics II	3	1	0	30	20	50	100	150	4
5		Chemical Technology I	2	1	0	15	10	25	50	75	3
6		Engineering Economics	2	0	0	15	10	25	50	75	2
PRACTICAL/DESIGN/DRAWING											
7		Mass Transfer Lab - II	0	0	3	10	10	20	30	50	1
8		Chemical Reaction Engineering Lab - I	0	0	3	10	10	20	30	50	1
9		Chemical Technology Lab	0	0	2	10	10	20	30	50	1
10		Flow Sheeting Lab	0	0	2	10	10	20	30	50	1
11		GP						50		50	
		TOTAL	16	5	10					1000	25

B.TECH III YEAR VI SEMESTER
CHEMICAL ENGINEERING

S. No.	CourseCode	Subject	Periods			Evaluation Scheme				Subject Total	Credits
						Sessional Exam.			ESE		
			L	T	P	CT	TA	Total			
THEORY SUBJECTS											
1		Chemical Reaction Engineering II	3	1	0	30	20	50	100	150	4
2		Chemical Technology II	3	1	0	30	20	50	100	150	4
3		Process Dynamics and Control	3	1	0	30	20	50	100	150	4
4		Piping Design	3	1	0	30	20	50	100	150	4
5		Process Instrumentation	2	1	0	15	10	25	50	75	3
6		Industrial Management	2	0	0	15	10	25	50	75	2
PRACTICAL/DESIGN/DRAWING											
7		Chemical Reaction Engineering Lab - II	0	0	3	10	10	20	30	50	1
8		CAD and Simulation Lab	0	0	2	10	10	20	30	50	1
9		Process Dynamics and Control Lab	0	0	2	10	10	20	30	50	1
10		SEMINAR	0	0	3		50	50		50	1
11		GP						50		50	
		TOTAL	16	5	10					1000	25

B Tech. Chemical Engineering

4th Year VII-SEMESTER **Session- 2017-18**

Sl No.	Subject Code	Subject Name	L-T-P	Th/Lab Marks	Sessional		Total	Credit
					Test	Assig/ Att.		
1	BT-***	Human Value	3---0---0	70	20	10	100	3
2	BT-***	IPA & Waste Management	3---0---0	70	20	10	100	3
3	BT-***	Energy Engg. & Management	3---1---0	70	20	10	100	4
4	BT-***	Process Modeling & Simulation	3---0---0	70	20	10	100	3
5	BT-***	Process Design & Economics	3---1---0	70	20	10	100	4
6	BT-***	CAD Lab	0---0---2	50		50	100	1
7		Energy Lab	0---0---2	50		50	100	1
8		Industrial Training	0---0---3			100	100	2
9		PROJECT-1	0---0---6			200	100	3
	TOTAL						**1000**	**24**

B Tech. Chemical Engineering

4th Year VIII- SEMESTER **Session- 2017-18**

Sl No.	Subject Code	Subject Name	L-T-P	Th/Lab Marks	Sessional		Total	Credit
					Test	Assig/ Att.		
1	BT-***	Renewable Energy Resources	3---0---0	70	20	10	100	3
2	BT-***	Fertilizer Technology	3---1---0	70	20	10	100	4
3	BT-***	Petrochemical Technology	3---0---0	70	20	10	100	3
4		Seminar	0---0---3			100	100	2
5		Project-2	0---12---0	350		250	600	12
	TOTAL						**1000**	**24**

B.Tech in Chemical Engineering		
Semester	**Course Name and Course Code**	**Course Outcomes (Cos)**
3rd	**Mechanical Operation**	On completion of this course, the students will be able to CO1.Measure the particle size, CO2.Estimate the crushing efficiency of different type's crushers. CO3.Explain the particle sedimentation. CO4.Design the storage area for the different types of solids
3rd	**Material and Energy Balance**	After completion this course students will be able to understand :- CO1.Ability to make material balances on unit operations and processes CO2.Ability to perform simultaneous material and energy balances CO3.Understanding of the degrees of freedom analysis and its significance CO4.Understanding of the concept of humidity and usage of psychrometric chart
3rd	**Ch. Engineering Fluid Mechanics**	On completion of this course, the students will be able to CO1.Understand the properties and flow of fluid. CO2.Analyses the model and prototype. CO3.Explain the factors influencing velocity profiles for laminar and turbulent flow. CO4.Design the pumps and compressors for optimum operation.

3rd	**Polymer Sc. & Technology**	At the completion of this course, students should be able to CO1Understand the basic concepts of polymers CO2.To understand polymerization techniques and reactions CO3.Understand various transition of polymers. CO4.Understand basic knowledge of molecular weights. CO5.Understand the idea of polymer degradation.
3RD	**Environmental Pollution Monitoring & Control**	Course Objective: 1.The aim of this course is that the students will learn the essential principles used in different type of environmental pollution and understand important issues in environmental pollution monitoring and control. Course Outcomes CO1.Understand environmental regulatory legislations and standards and climate changes. CO2.Understand about the quantification and analysis of wastewater and treatment. CO3.Understand the different unit operations and unit processes involved in conversion of highly polluted water to potable standards. • CO4.Understand the atmospheric dispersion of air pollutants, and operating principles, design calculations of particulate control devices..
3rd	**Human Values & Professional Ethics**	CO1: Understand and analyse the essentials of human values and skills, self exploration, happiness and prosperity. CO2: Evaluate coexistence of the "I" with the body. CO3: Identify and evaluate the role of harmony in family, society and universal order. CO4: Understand and associate the holistic perception of harmony at all levels of existence.

		CO5: Develop appropriate technologies and management patterns to create harmony in professional and personal lives.
4th	**Mass Transfer -1**	On successful completion of the course, the student will be able to: CO1.Understand the principles of molecular diffusion and basic laws of mass transfer. CO2.Utilize mass transfer concepts to design gas absorption systems. CO3.Discuss the basics of humidification process and its application CO4.Explain the concept and mechanism of drying operations. CO5.Analyze the concept of crystallization process and identification of suitable crystallizer.
4th	**Environment and Ecology**	On successful completion of the course, the student will be able to: CO1.Understand the impact of environmental pollution and concept of sustainable development CO2.Analyze various resource conservation methodologies. CO3.Design of various air pollution and water pollution control equipments. CO4.Apply the basic scientific and sustainability principles behind waste management for solving practical CO5.waste management challenges Discuss the ethical and moral issues involved in seeking the sustainable use of resources
4th	**Ch. Engineering Thermodynamics**	After completion of this course, student will be able to: CO1.Ability to apply fundamental concepts of thermodynamics to engineering applications .

		CO2.Ability to estimate thermodynamic properties of substances in gas and liquid states. CO3.Capability to determine thermodynamic efficiency of various energy related processes.
4th	**Heat Transfer**	After completion of this course, student will be able to: CO1.Ability to understand and solve conduction, convection and radiation problems CO2.Ability to design and analyze the performance of heat exchangers and evaporators CO3.Ability to design and analyze reactor heating and cooling systems. CO4.Students will able to correlate the all possible mode of heat transfer and application the same on industrial scales.
4th	**Process Instrumentation**	**On completion of this course student will be able to** CO1.Knowledge of field instrumentations CO2.Dynamic modeling and system behavior study CO3.Design of controllers • Application of control systems in processes
5TH	**Chemical Reaction Engineering I**	After completion of this course, student will be able to: CO1.Identify the reaction type and their kinetics. CO2.Design the reactor for the batch and continuous chemical process. CO3.Understand the Ideal and Non – Ideal Reactors.

		CO4.Understand the concept of different arrangements of chemical reactors for optimum conversion. CO5.Industrial use of chemical reaction engineering for production and economic growth.
5th	**Thermodynamics II**	After completion of this course, student will be able to: CO1.Ability to apply fundamental concepts of thermodynamics to engineering applications . CO2.Ability to estimate thermodynamic properties of substances in gas and liquid states. CO3.Capability to determine thermodynamic efficiency of various energy related processes.
5th	**Engineering Economics**	After completion of this course, student will be able to: CO1.The students will understand the basic concepts and terminology used in engineering economics. CO2.The students will be able to use the concepts of cash flows, time value of money in evaluation of investments and projects in real life CO3.The students will be able to compare and evaluate alternatives based on present, annual, rate of return, and benefit over cost analyses CO4.The students will be able to identify and analyse the impact of depreciation, taxation and other economic factors on feasibility of real life projects. CO5.The students will be able to recognize the economic impact of engineering solutions and Conduct sensitivity analysis on key compounding

		parameters, so as make financially prudent decisions in everyday life.
5th	**Chemical Technology I**	After completion of this course, student will be able to: CO1.Ability to understand the manufacturing of various inorganic and organic chemicals CO2.Ability to understand the process flow diagram and various process parameters CO3.Ability to identify and solve engineering problems during production. CO4. Students will understand the industrial application and utilization of chemical technology.
5th	**Transport Phenomenon**	On completion of this course, the students will be able to CO1.Understand the chemical and physical transport processes and their mechanism CO2.Do heat, mass and momentum transfer analysis samultaneously. CO3.Analyze industrial problems along with appropriate approximations and boundary conditions CO4.Develop steady and time dependent solutions along with their limitation
5TH	**Mass Transfer -II**	Students completing the course will be able to CO1.Understand the basics of distillation process for separation. CO2.Determine number of stages in distillation, absorption and extraction operations CO3.Determine the height of packed column in

		absorption, distillation and extraction CO4.Analyze the distillation process for binary and multicomponent mixtures CO5.Determine the number of stages required for separation of liquid-liquid and solid-liquid extractionprocess. CO6.Solvent selection for absorption and extraction operations
6th	**Chemical Reaction Engineering II**	After successful completion of the course the students will be able to: CO1Classify catalysts and predict physical properties of catalyst, surface area, void volume, solid density pore volume distribution. CO2.Understand the nature and mechanism of catalytic reactions and predict the rate controlling step reactions. CO3.Analyze the various contacting pattern for two phase system. CO4.Predict the rate equation for heterogeneous reactions and understand the effect of velocity, particle size and fluid properties on rate of reactions controlled by mass transfer CO5.Analyze the best kinetic regimes for mass transfer and reaction and predict the rate equation. CO6.Understand the nature and mechanism of Biochemical reactions. CO7.Understand the working of Biochemical and polymerization reactors.
6TH	**Chemical Technology II**	After successful completion of the course the students will be able to: CO1.Ability to understand the manufacturing of various inorganic and organic chemicals

		CO2.Ability to understand the process flow diagram and various process parameters CO3.Ability to identify and solve engineering problems during production
6th	**Process dynamic control**	**On completion of this course student will be able to** CO1Demonstrate fundamental understanding of process control. CO2.Develop transfer function (input-output) and models for linear dynamical process. CO3.Characterize the dynamics and stability of processes based on mathematical analysis. CO4.Develop the mathematical models for various chemical processes. CO5.Explain different control modes and their application in controlling various processes. CO6.Explain the working of different controllers and valves.
6th	**Process Instrumentation**	**On completion of this course student will be able to** CO1.Knowledge of field instrumentations CO2.Dynamic modeling and system behavior study CO3.Design of controllers • Application of control systems in processes
6th	**Piping Design**	**On completion of this course student will be able to** CO1.Describe the responsibilities of piping field engineer. CO2.Use pipe's standard tables for different calculations.

		CO3.Describe the functions and features of various piping components/Element CO4. Apply various codes and standard for piping in a given situation. CO5.Measure pressure in pipes. vi. Explain precautions to be taken in piping fabrication to minimise loss in head due to flow of fluid through piping. CO6.Interpret and use various simple piping drawings in a given situation viii. Plan and supervise process of surface preparation and painting/coating. CO7.Perform the process of pipe shaping, bending and forming
6th	**Industrial Management**	After successful completion of the course the students will be able to: CO1.choose, prepare, interpret and use cost estimates as a basis for the different situations in an industrial company, CO2.interpret financial statements and other financial reports of industrial companies, including the income statement, the balance sheet, the cash flow statement, key measures, budget and sustainability analysis in these, CO3.explain how the industrial company can be organised and managed, CO4.explain the industrial company's value creating processes, how the company can price it's products and how the company works in it's environment.
7th	**Human Values**	After completion of this course, student will be able to: CO1. To help the students having the clarity about human aspirations, goal, activities and purpose of life. CO2. To facilitate the competence to

		understand the harmony in nature/existence and participation of human being in the nature/existence. CO3. To help the students to develop the understanding of human tradition and its various components.
7th	**ENERGY ENGINEERING & MANAGEMENT**	Students completing the course will be able to CO1. Provide an overview of renewable and non-renewable energy resources scenarios. CO2. Perform energy audits in various unit operations. CO3. Able to understand the principles and technologies involved in alternate sources of energy CO4. Explore the energy conservation opportunities in chemical process utilities CO5. Study the case studies of energy conservation in chemical process industries
7th	**Process modelling and simulation**	CO1. Identify the terms involved in inventory rate equation of mass, energy and momentum CO2. Recall the basic concepts involved in modeling and simulation CO3. Apply conservation of mass, momentum and energy equations to engineering problems. CO4. Develop model equations for chemical engineering systems CO5. Solve the model equations and chemical engineering problems using numerical techniques.
7th	**IPA & Waste Management**	CO1: Identify improper practices of solid waste disposal and their environmental implications. Know the basic engineering principles of solid waste management CO2: Describe the need for economics in collection and transportation of solid waste and clearly discuss

		various types of collection systems and analyse system dynamics. CO3: Understand the management concepts, define 4 R approach, apply PPP model and community involvement for effective management of solid waste. CO4: Develop a concise idea on various conventional and advanced treatment options for solid waste. CO5: Conceive the design aspects of engineered disposal options and apply the gained knowledge to solve numerical examples.
8th	**Fertilizer Technology**	After completion of this course, student will be able to: CO1.Use reactions and unit operations steps in manufacturing of various fertilizers CO2.Identify engineering problems in fertilizer manufacturing. CO3.Select appropriate synthesis fertilizer
8th	**Renewable Energy Resources**	After completion of this course, student will be able to: CO1.To know the energy demand of world, nation and available resources to fulfill the demand CO2.To know about the conventional energy resources and their effective utilization To acquire the knowledge of modern energy conversion technologies CO3.To be able to understand and perform the various characterization techniques of fuels CO4.To be able to identify available nonconventional (renewable) energy resources and techniques to utilize them effectively.

8th	**Petrochemical Technology**	Students completing the course will be able to CO1. Describe the process of crude oils production & refining and Characteristics of crude oils CO2. Understand the various quality Control parameters of Petroleum Products CO3. Describe the physical properties of petroleum products and thermal conversion of petroleum products CO4. Understand the process involved in catalytic conversion CO5. Demonstrate the different methods available for lube oil manufacturing process.
7th	**Human Values**	After completion of this course, student will be able to: CO1. To help the students having the clarity about human aspirations, goal, activities and purpose of life. CO2. To facilitate the competence to understand the harmony in nature/existence and participation of human being in the nature/existence. CO3. To help the students to develop the understanding of human tradition and its various components.

B.Tech in Chemical Engineering		
Semester	**Course Name and Course Code**	**Syllabus**
3rd	**Mechanical Operation**	UNIT I Types of Mechanical Operations, screen analysis, particle size distribution, particle size measurement, Surface area measurements, statistical mean diameters, relevant equations and problems. UNIT II Laws of crushing and grinding. Classification of crushing and grinding equipment. Construction and working principle of crushers and grinders.

		UNIT III Classification of conveyors, Storage of solids in bulk protected and unprotected piles, bines, silos, hoppers, mass flow and funnel flow Bins, Flow assisting devices, feeders. Mixing of solids, blending, kneading. Weighing of bulk solids, batch and continuous weighing techniques. UNIT IV Rare and dense medium separation, classifiers, magnetic separation, electrostatic separator, floatation and elutriation, continuous thickeners, decantation, centrifugal separation, Gravity settling, cyclone separators, bag filters, scrubbers. UNIT V Classification of filters, theory of filtration, cake resistance. Fluidization with and without carryover of particles, minimum fluidization, terminal velocity of particles, entrainment, pressure drop in fluidization. BOOKS: 1. Momentum transfer operation: S.K. Gupta, TMC, 1979. 2. Unit Operations of Chemical Engineering: McCabe and Smith, TMC 3. Chemical Engineering Vol. I: Coulson & Richardson, Pergamon, 1979
3rd	**Material and Energy Balance**	**UNIT I** Basic and derived units, use of model units in calculations, Methods of expression, compositions of mixture and solutions, Ideal and real gas laws - Gas constant - calculations of pressure, volume and temperature using ideal gas law, Use of partial pressure and pure component volume in gas calculations, applications of real gas relationship in gas calculation. **UNIT II** Stoichiometric principles, application of material balance to unit operations like distillation, evaporation, crystallization, drying etc., Material balance with chemical reaction, Limiting and excess reactants, recycle, bypass and purging **UNIT III** Unsteady state material balances, calculation of absolute humidity, molal humidity, relative humidity and percentage humidity, use of humidity in condensation and drying, Humidity chart, dew point.

		UNIT IV Determination of Composition by Orsat analysis of products of combustion of solid, liquid and gas fuels, calculation of excess air from orsat technique and problems, heat capacity of solids, liquids, gases and solutions, use of mean heat capacity in heat calculations, problems involving sensible heat and latent heats, evaluation of enthalpy. **UNIT V** Standard heat of reaction, heats of formation, combustion, solution, mixing etc., calculation of standard heat of reaction, effect of pressure and temperature on heat of reaction, Energy balance for systems with and without chemical reaction, unsteady state energy balances. Introduction to Computer aided calculations-steady state material and energy balances. **BOOKS:** 1. Bhatt, BL, VORA, S.M., "Stoichiomentry", Tata McGraw-Hill, 1976. 2. Hougen, OA, Watson, K.M and Ragatz, RA, "Chemical Process Principles Part-I", John Wiley and Asia Publishing, 1970. 3. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering ", Fourth Edition, Prentice Hall Inc., 1982. 4. Whitwell, JC, Tone, RK, "Conservation of Mass and Energy", McGraw-Hill, 1973. 5. Process Calculation for Chemical Engineering, Second Revised Edition, Chemical Engineering Education Development Centre, IIT Madras, 1981.
3rd	**Ch. Engineering Fluid Mechanics**	**UNIT I** Properties of fluids, fluid statics, Forces on fluids, pressure depth relationship for compressible and incompressible fluids, Forces on submerged bodies, Rigid body motion, pressure measurements, Euler's equation, Bernoulli's theorem. **UNIT II** Kinematics of flow, Description of velocity field, Stream functions, Angular velocity, Fluids in circulation, Irrotational flow, Dimensional analysis, Buckingham Pi Theorem, Dimensionless numbers and their physical significance, Similitude Criteria. **UNIT III**

		Fluid flow: Laminar and turbulent flows, Pressure drop in pipes, pipe fittings and pipe network, friction factor, Conservation of mass, momentum and energy, Mechanical engineering Bernoulli's equation . **UNIT IV** Flow measuring devices for chemical plants, venturimeter, orifice meter, nozzle, Rotameter, pitot tube and v-notch. **UNIT V** Pumping and compressing of chemicals and gases, reciprocating pumps, rotary pumps, centrifugal pumps and blowers, NPSH and calibrations, mixing and agitation, types of mixers and their selection, power requirement, compressible fluid flow, introductory concepts of two-phase flow. **BOOKS:** 1. Gupta, Vijay and SK Gupta, "Fluid Mechanics and its Applications", Wiley Eastern, New Delhi (1984). 2. Rajput, RK, "Text Book of Fluid Mechanics", S. Chand and Co., New Delhi (1998). 3. Jain, AK, "Fluid Mechanics including Hydraulic Machines", Khanna Publishers, Delhi (2007). 4. Bansal, RK, "Fluid Mechanics and Hydraulic Machines", Laxmi Publications (P) Ltd., New Delhi (2005). 5. Gupta, SK, "Momentum Transfer Operations", Tata McGraw Hill, New Delhi (1982).
3rd	**Polymer Sc. & Technology**	**UNIT I** History of polymer science, Classification of Polymers, Functionality and structure of polymers, Physical properties and characterization of polymers, effect of structure on properties of polymers, Inorganic polymers. Concept of macromolecules. Stereochemistry of polymers. **UNIT II** Introduction, Chain & step growth polymerization, Polymerisation techniques, Kinetics of Polymerisation (Free radical, Cationic, Anionic polymerization, Polycondensation). **UNIT III**

		Molecular weight, Number average and weight average molecular weight, Sedimentation and Viscosity average molecular weight, Molecular weight and degree of polymerization, Polydispersity, Size of polymer molecules. **UNIT IV** Glass transition temperature, Transitions, significance and factors influencing the Tg. Effect of Plasticizers on Tg. Glass transition of copolymers. Morphology and order of Polymers, Crystallinity in polymers, Degree of crystallinity and Polymer crystallization.Effect of crystallinity on properties of Polymers. **UNIT V** Polymer degradation and stability.Types of degradation.Mechanism of degradation.Factors affecting degradation. Polymer solutions. Process of dissolution of polymers.Thermodynamics of Dissolution. Flory-Huggins Theory, Viscosity of Polymeric solutions. Books and References: 1. Plastics Material, Brydson, J.A 2. Text Book of Polymer Science, Billmeyer, Fred W. 3. Principles of Polymer Systems By Ferdinand Rodriguez 4. Principles of Polymer Chemistry By A. Ravve 5. Introduction of Polymer Science By Hans-Georg Elias 6. Polymer Science & Technology By Joel R. Fried. 7. Polymer Science By Gowariker V R, Vishwanathan NV, Jayadev Sreedhar.
3RD	**Environmental Pollution Monitoring & Control**	**UNIT I** **Introduction**: Ecology & Environment, Biodiversity, Interaction of man and environment, Overall picture of Environmental pollution, Ambient air and water quality criteria, Standards and Acts-Indian, EPA& EURO, Effects and control of noise, thermal and radioactive pollution. **UNIT II** **Air Pollution**: Types of pollutants, Dispersion of pollutant in the atmosphere, Gaussian dispersion model, Meteorological factors, Stability and inversion of atmosphere, Plume Behaviour, Control of air pollution from stationary and mobile sources, Methods of measuring and sampling of gaseous and particulate pollutants in ambient air and industrial waste gases, measurement of smoke density and visibility .Control of gaseous pollutants- SOx, NOx, H2S, VOCS,

		Auto exhaust. Stack design, Classification, selection and design of equipment's like cyclones, electrostatic precipitators, bag filters, wet scrubbers, settling chambers. **UNIT III** **Water Pollution**: Waste water characteristics – Physical and chemical composition, Biochemical oxygen demand (BOD), Pathogenic bacteria and chemical toxicity. Types of pollutants in waste water of chemical industries, Methods of sampling, preservation of samples and analysis. Methods for the treatment of liquid wastes to control pollution, Classification viz. physical, chemical and biological methods, Selection and design of equipment like hydrocyclone, settling tanks, filters, ion- exchange. **UNIT IV** **Solid Wastes Management**: Characterization of solid wastes, Problems of collection and handling, Various processing techniques used in solid waste management such as compaction, incineration, Composting, landfills and biological Processing, Solid waste as resource material. **UNIT V** Pollution abatement in important chemical industries like fertiliser, petroleum refineries and petrochemicals, Pulp and Paper, Pharmaceuticals, Tannery, Sugar, Distillery, food processing , cement and electroplating. **Text Books** 1. Howard S. Peavy, DR Rowe & C. Tchobonoglous "Environmental Engineering", McGraw Hill (1984). 2. Metcalf & Eddy, "Waste Water Engineering Treatment, Disposal & Reuse", Tata McGraw Hill (2003). **Reference Books** 1. Werner Strauss, 'Air Pollution Control: Measuring and monitoring air pollutant', Wiley (1978). 2. Werner Strauss, 'Air Pollution Control part -II, Wiley (1978). 3. Pandey, GN and Carney, GC, "Environmental Engineering", Tata McGraw Hill (1991).
4th	**Mass Transfer -1**	**UNIT I** **Diffusion:** Molecular and turbulent diffusion, diffusion coefficient, Fick's Law of diffusion, dependence of diffusion coefficient on temperature, pressure and composition; measurement and estimation of diffusivity. Diffusion in multi-component gas mixtures. Diffusion in Solids: Molecular, Knudsen &surface

		diffusion; Inter- phase mass transfer: Mass transfer coefficients, Diffusion between phases, Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in fluidized beds, Flow past solids and boundary layers, Simultaneous heat and mass transfer. **UNIT II** **Absorption and Stripping:** Equipments, Gas-liquid equilibria, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, HTU, NTU & HETP concepts, Design equations for packed column, Absorption with chemical reaction and mass transfer. **UNIT III** **Humidification and Dehumidification:** Vapour liquid equilibrium and enthalpy for a pure substance, vapour pressure temperature curve, Vapour gas mixtures, Definition and derivations of relationships related with humidity Fundamental concept of humidification, Dehumidification and water cooling, Wet bulb temperature, Adiabatic and non-adiabatic operations, Evaporative cooling ,Classification and design of cooling towers. **UNIT IV** **Drying:** Solid-gas equilibria, Different modes of drying operations, Definitions of moisture contents, Types of batch and continuous dryers, Rate of batch drying, Time of drying, Mechanism of batch drying, Continuous drying, Design of continuous dryers. **UNIT V** **Crystallisation:** Equilibrium yield of crystallization ,Heat and mass transfer rates in crystallization, Theories of crystallization, Factors governing nucleation and crystal growth rates, Controlled growth of crystal., Classification and design of crystallizers. **Text Books** 1. Treybal, R "Mass Transfer Operations", 3rd ed. NewYork:McGraw-Hill, (1980). 2. Sherwood T. K., Pigford R. L. and _ilkeP. "Mass Transfer"McGrawHill (1975).

		Reference Books 1. Foust, AS et.al., "Principles ofUnit Operations" John Wiley (1980). 2. Geankoplis, CJ, "Transport Processes and Unit Operations", 3rd ed. Prentice
4th	**Environment and Ecology**	**UNIT-I:** Nature of Environment Introduction to Environmental Science - Definition and scope and need for public awareness Ecosystems Concept, structure and functions, restoration of damaged ecosystems Biodiversity – Definition, description at national and global level, threats and conservation Natural Resources - Renewable and non-renewable and their equitable use for sustainability, Material cycles – carbon, nitrogen and sulphur cycle. Conventional and Non-conventional Energy Sources – fossil fuel-based, hydroelectric, wind, -nuclear and solar energy, biomass, biodiesel, hydrogen as an alternative fuel **UNIT-II:** Impact of Human Activity on Environment Human Population and Environment – Population growth, population explosion and migration; Impact of farming, housing, mining, transportation and industrial growth Social Issues Related to Environment– Sustainable development, urban problems (related to water and energy conservation and waste management), resettlement and rehabilitation Environmental ethics **UNIT-III:** Environmental Changes and Human Health Environmental Pollution– Definition, causes and effects, control measures for water, air, soil, marine, land, noise, thermal pollution, Climate change– Greenhouse effect and global warming, acid rain, ozone layer formation and depletion Impact on human health – water and air borne diseases, diseases induced by residual impurities in drinking water (fluoride and arsenic); Toxic wastes and carcinogens; Nuclear hazards **UNIT- IV:** Environmental Protection through Assessment and Education Indicators and Impact Assessment – Bio-indicators, Natural disasters and disaster management, Impact assessment through inventorying and monitoring Environmental

		Protection– Role of individuals, organizations and government in pollution control Laws, Conventions and Treaties–National legislation, issues in the enforcement of environmental legislation, initiatives by non- governmental organizations, global efforts in environmental protection Environmental education–women and value education **Recommended Textbook:** Environmental Studies, J Krishnawamy , R J Ranjit Daniels, Wiley India. Recommended Reference Books: 1. Environmental Science, Bernard J. Nebel, Richard T. Right, 9780132854467, Prentice Hall Professional 1993. 2. Environment and Ecology, R K Khandal, 978-81-265-4277-2, Wiley India. 3. Environmental Science, 8th Ed ISV, Botkin and Keller, 9788126534142, Wiley India. 4. Environmental Studies, R Rajagopalan, 978-0195673937, Oxford University Press 5. Textbook of Environmental Science and Technology, M.Anjireddy, BS Publications 6. Environmental Studies, Soli. J Arceivala, Shyam, R Asolekar, 9781259006050, McGrawHill India, 2012. 7. Environmental Studies, D.L. Manjunath, 9788131709122 Pearson Education India, 2007 8. Textbook of Environment Ecology , Singh, Acme Learning 9. Perspective in Environmental Studies, Kaushik, New Age International 10. Environmental Studies, B. Joseph, 2nd Ed, 978-0070648134, Tata McGraw Hill
4th	**Ch. Engineering Thermodynamics**	Basic concept and definitions in thermodynamics, first, second and third laws of thermodynamics and it application in engineering problems, energy balance for open and closed systems. Entropy and entropy balance for open systems. **UNIT II** An Introduction to Vapour-Liquid Equilibria, qualitative behaviour of the vapour-liquid equilibria (VLE), Simple models for vapour liquid equilibria: Raoult's and Henry's laws, dew point and bubble point calculations, VLE by modified raoult's law and K-value correlations. **UNIT III**

		Solution Thermodynamics: Theory and Applications, fundamental property relation. The chemical potential and phase equilibria. Partial properties, equations relating molar and partial molar properties, partial properties in binary solutions, relations among partial properties, ideal gas mixtures, fugacity and fugacity coefficient for pure species, VLE for pure species, fugacity of a pure liquid, fugacity and fugacity coefficient for species in solution, the fundamental residual property relation, fugacity coefficients from the virial equation of state and generalized correlations, the ideal solution, the Lewis/Randall rule, excess properties. The excess Gibbs energy and the activity coefficient, nature of excess properties. **UNIT IV** **Chemical Reaction Equilibria:** The reaction coordinate. Multireaction stoichiometry. Application of equilibrium criteria to chemical reactions. The standard Gibbs energy change and equilibrium constant. Effect of temperature on the equilibrium constant. Evaluation of equilibrium constants. Relation of equilibrium constants to composition. Gas-phase and liquid-phase reactions. Equilibrium conversions for single reactions. Single phase reactions. **UNIT V** Topics in Phase Equilibria The gamma/phi formulation of VLE.VLE from cubic equations of state. Equilibrium and stability. Liquid-liquid equilibrium. Vapour-liquid-liquid equilibrium. Solid-liquid equilibrium. Osmotic equilibrium and osmotic pressure. **BOOKS** 1. Cenjel Y.A. and Boles M.A.; Thermodynamics: An Engineering Approach 2. Smith, J. M.; Introduction to chemical engineering thermodynamics.
4th	**Heat Transfer**	**UNIT I** Introduction to heat transfer and general concepts of heat transfer by conduction, convection and radiation, Conduction: Basic concepts of conduction in solids, liquids, gases, steady state temperature fields and one dimensional conduction without heat generation e.g. through plain walls, cylindrical and spherical surfaces, composite layers, etc. Insulation materials, critical and optimum

		insulation thickness. Extended surfaces, fins and their applications. Introduction to unsteady state heat transfer. **UNIT II** Convection: Fundamentals of convection, Basic concepts and definitions, natural and forced convection, hydrodynamic and thermal boundary layers, laminar and turbulent heat transfer inside and outside tubes. Determination of individual and overall heat transfer coefficients, heat transfer in molten metals. **UNIT III** Radiation: Basic laws of heat transfer by radiation, black body and gray body concepts, view factors, Kirchhoff's law, solar radiations, combined heat transfer coefficients by convection and radiation. **UNIT IV** Heat transfer with phase change: Condensation of pure vapors, film wise and drop wise condensation, loading in condensers and basic calculation on condensers. Heat transfer in boiling liquids, boiling heat transfer coefficients. Evaporation: Elementary principles, types of evaporators, Single and multiple effect evaporators and their calculations. **UNIT V** Heat transfer equipment: Classification, principles and design criteria, types of exchangers, viz. double pipe, shell and tube, extended surface. Furnaces and their classification and application. **BOOKS :** 1. Holman, JP, "Heat Transfer", 9th ed. McGraw Hill (1989). 2. Coulson, JM & Richardson, JF, "Chemical Engineering: Vol-1", 6th ed. Butterworth-Heinemann 3. McAdams, W. H., "Heat Transmission", 3rd ed., McGraw-Hill (1954). 4. Kern, DQ, "Process Heat Transfer", McGraw Hill Book (1950). 5. Badger, WL & Bancharo, JT, "Introduction to Chemical Engineering", Tata McGraw
4th	**Process Instrumentation**	**UNIT I** Importance of measuring of Instruments in Process Control, Classification of Instruments, Elements of an Instruments, Static & Dynamic Characterization of

		Instruments, Errors in measurements & Error Analysis, Selection of instrument for a particular Measurement, transducers. **UNIT II** Measurement of Temperature: Thermocouples, Resistance Thermometer, Expansion Thermometers, Pyrometers. **UNIT III** Measurement of Pressure & Vacuum, Hydrostatic type , Elastic Element type, Electrical Type and other type of instruments like McLeod Gauge, Thermocouple gauge, Knudson Gauge, Ionization Gauge. **UNIT IV** Instruments for Measurement of Flow rate & level: Variable Area & variable head flow meters, Volumetric and Mass flow rate meters, Linear velocity measurement systems, Anemometers, Pressure type, Resistance & Capacitance type, Sonic & Ultrasonic, Thermal type Level meters. **UNIT V** Instruments for Measurement of Viscosity: Redwood, Saybolt, Engler, Cup & Cone type, Rheo & other types of viscometers. **Books:** 1. Eckman, D.P., Industrial Instrumentation, Wiley Eastern Ltd., New York 1990. 2. Jain, R.K., Mechanical and Industrial Measurements, Khanna Publishers.
5TH	**Chemical Reaction Engineering I**	UNIT 1 Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions. UNIT 2 Interpretation of variable volume batch reactions for zero, first and second order reactions, design equation for batch, continuous stirred tank, plug flow reactors for isothermal reaction.

		UNIT 3 Optimum reactor size, plug flow/mixed flow reactors in series and parallel, recycle reactor. UNIT 4 Design of reactors for multiple reactions, parallel and series reactions. Temperature and pressure effects for single reaction. UNIT 5 Residence time distribution of fluids in vessels, E, F and C curves, Dispersion model, Tank in series model. Non Isothermal PFR and CSTR, Safety issues in Non Isothermal Reactors. Text Books: 1. Smith, J, M, "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill (1990). 2. Levenspiel, O., "Chemical Reaction Engineering", 3rd Edition, John Wiley (1998). 3. Fogler, H.S., 2016. Elements of chemical reaction engineering. Reference Book: 1. Keith J. Laidler, "Chemical Kinetics" 3rd Edition, Pearson (2013)
5th	**Mass Transfer -2**	UNIT 1 Distillation: Basic fundamentals of distillation, Pressure-composition, Temperatureconcentration, Enthalpy- concentration diagrams for ideal and non-ideal solutions, Raoult's law and its application, Maximum and minimum boiling mixtures, concept of relative volatility, Single Stage Distillation Differential distillation, Flash vaporization, Vacuum, molecular and steam distillation. UNIT 2 Continuous Distillation of Binary Mixtures : Multistage contact operations, Characteristics of multistage tower, McCabe Thiele method, Ponchon Savarit method, Reflux, maximum, minimum and optimum reflux, Use of open steam, Tray efficiency, Determination of height and column diameter, Multistage batch distillation; Principles of azeotropic and extractive distillation, Introduction & Design of multicomponent distillation system. UNIT 3 Liquid-Liquid Extraction: Ternary liquid equilibria, Triangular graphical representation concept of theoretical or ideal stage, Equipment used for single stage and multistage continuous operation; Analytical and graphical solution of single and multistage operation Super critical fluid extraction. UNIT 4

		Solid /Liquid Extraction: Leaching, Solid liquid equilibrium, Equipment used in solid – liquid extraction, Single and multistage cross current contact and counter current operations. Concept of an ideal stage, Overall stage efficiency, Determination of number of stages. UNIT 5 Adsorption: Description of adsorption processes and their application, Types of adsorption, Nature of adsorbents adsorption equilibria and adsorption hysteresis, Stage wise and continuous contact adsorption operations, Determination of number of stages, Ion exchange Equipments, Equilibrium relationship, Principle, techniques and applications of Ionexchange, , Principles and application of Dialysis, Osmosis, Reverse osmosis, Thermal diffusion, Sweep diffusion. Text Books: 1. Treybal, R "Mass Transfer Operations", 3rd Editon, New York: McGraw-Hill, (1980). 2. Sherwood T. K., Pigford R. L. and Wilke P. "Mass Transfer" McGraw Hill (1975) Reference Books: 1. Foust A. S. et.al., "Principles of Unit Operations" John Wiley (1980). 2. Geankoplis, C.J.. "Transport Processes and Unit Operations", 3rd Editon, Prentice Hall. (1993) 3. Coulson, J. M. and Richardson J. F., "Chemical Engineering" Vol. I, II, IV & V: Pergamon Press. 4. Phillip C. Wankat, "Separation Process Engineering Includes Mass
5th	**Chemical Technology 1**	**UNIT 1** Introduction - Mono and Disaccharides - Important reactions - Polysaccharides - Starch and Cellulose - Derivatives of Cellulose - Carboxy Methyl Cellulose and gun cotton - Structural aspects of cellulose. **UNIT 2** Sugar, Glucose, Starch, Fermentation products such as Alcohol, Acetic acid, Citric acid and antibiotics **UNIT 3** Soap and Surfactants, Glycerin, Fatty acids, Hydrogenation of edible oils, paper and pulp **UNIT 4** Synthetic and natural fibers: Nylon, Dacron, Terylyne, Polyester and other new products, Viscose rayon, acetate rayon , synthetic rubber with special reference to manufacture, vulcanization and reclaiming of rubber, SBR, Plastics, Thermosetting and Thermo Plastics (PVC, Polyethylene, Polyurethane, Teflon) **UNIT 5** Crude oil distillation, Thermal conversion processes (visbreaking, coking), Catalytic conversion processes (fluid catalytic cracking, catalytic reforming, hydro cracking, alkylation, isomerisation, polymerization) Finishing processes, sulphur removal process, lub oil manufacture; Petrochemicals (ethylene,

		propylene, formaldehyde, methanol, ethylene oxide, ethanolamine, cumene, ethylene glycol, ethyl benzene) **Text Books:** 1. Dryden, C. E. "Outlines of Chemical Technology" (Edited and Revised by M. Gopala Rao and M. Sittig) East West Press. Pvt. Ltd, New Delhi, 3rd Edition (1997). 2. Austin G. T. Shreve's Chemical Process Industries", 5th Edition, McGraw Hill (1984). 3. O P Gupta, "Chemical Process Technology", Khanna Publishing House.
5TH	**Transport Phenomenon**	**UNIT 1** Vectors/Tensors, Newton's law of viscosity, Temperature, pressure and composition dependence of viscosity, Kinetic theory of viscosity, Fourier's law of heat conduction, Temperature, pressure and composition dependence of thermal conductivity, Kinetic theory of thermal conductivity, Fick's law of diffusion, Temperature, pressure and composition dependence of diffusivity, Kinetic theory of diffusivity. **UNIT 2** Shell Momentum balances, velocity profiles, average velocity, momentum flux at the surfaces, Equations of Change (Isothermal), equation of continuity, equation of motion, equation of energy (isothermal). **UNIT 3** Shell energy balances, temperature profiles, average temperature, energy fluxes at surfaces, Equations of change (non-isothermal), equation of continuity, equation of motion for forced and free convection, equation of energy (non-isothermal). **UNIT 4** Shell mass balances, concentration profiles, average concentration, mass flux at surfaces, Equations of change (multi-component), equations of continuity for each species, equation of energy (multi-component). **UNIT 5** Introduction to the concept of heat and mass transfer coefficients. Interphase mass transfer, various coefficient of mass transfer and their determination, resistance concept, controlling phase concept, Mass transfer in turbulent flow, Analogies of mass transfer, Empirical equations. Theories of mass transfer, two film theory, Higbies penetration theory, Derivation of flux equation, surface renewal theory. **Text Book:** 1. Byron, R. B., Stewart, W. E., Lightfoot, E. N., "Transport Phenomena", John Wiley & Sons, 1960.
6th	**Chemical Reaction Engineering II**	**UNIT 1** Introduction to heterogeneous reactions, rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics, Fluid-fluid reactions: kinetics and design. **UNIT 2** Fluid-solid reactions, experimental methods for finding rates, selection of a model, shrinkingcore model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling step, kinetic and design, Design of packed bed and fluidized bed reactors. **UNIT 3** Nature of catalysis, Determination of surface area, void volume and solid density, porevolume distribution, physical and chemical adsorption, adsorption isotherms, Physical properties of catalysts, preparation, testing and characterization of solid catalysts, catalyst selection, catalyst preparation,

		promoters and inhibitors, catalyst poisoning and mechanisms of catalytic reactions, catalyst deactivation. **UNIT 4** Reaction and diffusion within porous catalysts, effectiveness factor, various resistances to transfer of reactants to the catalyst site, intrinsic and global rate of reaction, kinetic regimes, heat effects during reaction, Performance equations for reactors containing porus catalyst particles, design of solid catalytic reactors. **UNIT 5** Biochemical reactors, polymerization reactors. **Books:** 1. Smith, J, M, "Chemical Engineering Kinetics", 3rd Edition, McGraw-Hill (1990). 2. Levenspiel, O., "Chemical Reaction Engineering", 3rd Edition, John Wiley, (1998). Reference Books: 1. Daizo Kunii & Octave Levenspiel, "Fluidization Engineering" 2nd Edition, Elsevier (India Print 2005) 2. Coulson and Richardson's Chemical Engineering Volume 3 - Chemical and Biochemical Reactors and Process Control (3rd Edition)
6TH	**Piping Design**	**UNIT 1** **Analysis of pipe flow:** Energy losses in pipe lines, concept of equivalent length and equivalent pipes, problems in pipe flow, hydraulic power transmission through a pipe line. **UNIT 2** Negative pressure in pipe lines, Siphon, Multiple pipe systems, working pressure, design pressure, choice of pipe materials, hydraulic analysis of complex pipe networks. **UNIT 3** Aids in selecting pipe valves and fittings, standards for piping design, Dimensional and mechanical standards for pipe valves and fittings. **UNIT 4** **Process piping arrangement** plant layout and equipment arrangement, criteria for equipment layout, piping layout and arrangement. **UNIT 5** Pipe fabrication, vibration, its prevention and control in piping systems. **Books:** 1. King, R. C. and Croker, S., "Piping Handbook", McGraw Hill. 2. Kellogg, M. W Company., "Design of Piping Systems", Pullman Power Products, New York (1976).
6th	**Process dynamic & control**	Dynamic modeling of first and second-order process; Interacting and non-interacting processes; Nonlinear and integrating processes; introduction to non-minimum phase processes; Distributed parameter processes and MIMO processes; Response of first and second orderprocesses with respect to different types of forcing functions. **UNIT 2** Experimental estimation of dynamic process parameters and identification. Modes of control action: Classification ofcontrollers and control strategy. **UNIT 3** Closed loop feedback control: Servo and regulator problems; Offset; Selection of mode of control action; Closed loop response; **UNIT 4**

		Routh stability criterion; Controller tuning and design:, Online tuning- closed loop and open loop methods. Frequency response technique: Phase margin and gain margin; Bode stability criterion; Nyquist stability criterion; Controller design. Root locus plot and stability analysis. **UNIT 5** Cascade and feed forward control: Design of controller and analysis of control system. Ratio, Adaptive, Model-based, Multivariable, Selective and Split range control. Computer process control **Text Book:** 1. Coughnaowr, D. R., "Process Systems Analysis and Control", McGraw-Hill, Inc. 2. Stephanopolous, G., "Chemical Process Control", Prentice-Hall. **Reference Books:** 1. Seborg, D. E., Edgar, T., and Mellichamp, D. A., "Process Dynamics and Control", John Wiley and Sons. 2. Bequette, B. W., "Process Control: Modeling, Design, and Simulation", Prentice-Hall,Inc. 3. Chidambaram, M., "Computer Control of Processes" Narosa Publishing House Pvt. Ltd., Ind. 4. D.C. Sikdar, " Instrumentation and Process Control", Khanna Book Publishing
6th	**Process Instrumentation**	**UNIT 1** Introduction to process variables; Static and dynamic characteristics of instruments and their general classification. Elements of measuring system and their functions; Signal transmission; Transmitters - Electronic, pneumatic, transducers. **UNIT 2** Principles, construction and operations of instruments for the measurement, transmission, control/ indication/ recording of various process variables such as temperature, pressure, flow, liquid level, humidity and composition. **UNIT 3** Principles and construction of electro-pneumatic transducer, pneumatic to electrical converter, multiplexers. Construction and characteristics of final control elements such as pneumatic control valve, stepper motor, motorized valve. **UNIT 4** Principles and construction of pneumatic and electronic controller. Introduction to data acquisition system and intelligent instruments. **UNIT 5** Process instrumentation diagrams and symbols: Instrumentation of process equipments such as distillation columns, heat exchangers, condenser, absorber, stripper, humidifier, evaporator and drier. **Text Books:** 1. Patranabis, D, "Principles of Industrial Instrumentation", Tata McGraw-Hill Publishing Co. Ltd. 2. Johnson, C. D., "Process Control Instrumentation Technology", Pearson Education, Inc. **Reference Books:** 1. Beckwith, T. G., Marangoni, R. D. and Lienhard, J. H., "Mechanical Measurements", Addison Wesley. 2. Jain, R. K., "Mechanical and Industrial Measurements", Khanna Publishers, New Delhi
7th	Human Value	Unit 1

		Introduction: The basic human aspirations and their fulfilment through Right understanding and Resolution; All-encompassing Resolution for a Human Being, its details and solution of problems in the light of Resolution Unit 2 Understanding Human being and its expansion. The domain of right understanding starts from understanding the human being (the knower, the experiencer and the doer); and extends up to understanding nature/existence – its interconnectedness and co-existence; and finally understanding the role of human being in existence (human conduct). Unit 3 Activities of the Self. Understanding the human being comprehensively is the first step and the core theme of this course; human being as co-existence of the self and the body; the activities and potentialities of the self; Reasons for harmony/contradiction in the self Unit 4 Understanding Co-existence with other orders. The need and the process of inner evolution (through self-exploration, self-awareness and self-evaluation)- particularly awakening to activities of the Self: Realization, Understanding and Contemplation in the Self (Realization of Co-Existence, Understanding of Harmony in Nature and Contemplation of Participation of Human in this harmony/ order leading to comprehensive knowledge about the existence). Unit 5 Expansion of harmony from self to entire existence. Understanding different aspects of All-encompassing Resolution (understanding, wisdom, science etc.), Holistic way of living for Human Being with All-encompassing Resolution covering all four dimensions of human endeavour viz., realization, thought, behavior and work (participation in the larger order) leading to harmony at all levels from self to Nature and entire Existence Reference Books:

		1. A Foundation Course in Human Values and Profession Ethics (Text Book and Teachers' Manual), R. R. Gaur, R. Sangal, G. P. Bagaria (2010), Excel Books, New Delhi [ISBN 978-8-174-46781-2] 2. Avartansheel Arthshastra, A. Nagraj, Divya Path Sansthan, Amarkantak, India 3. Economy of Permanence – (a quest for social order based on non-violence), J. C. Kumarappa (2010), Sarva-Seva-Sangh-Prakashan, Varansi, India 4. Energy and Equity, Ivan Illich (1974), The Trinity Press, Worcester & Harper Collins, USA 5. IshandiNauUpnishad, Shankaracharya, Geeta press, Gorakhpur, 6. Manav Vyavahar Darshan, A. Nagraj, Divya Path Sansthan, Amarkantak, India 7. Manaviya Sanvidhan, A. Nagraj, Divya Path Sansthan, Amarkantak, India 8. MahasatipatthanSutta , S N Goenka, Vipassana Research Institute, First Edition, 1996 9. Small Is Beautiful: A Study of Economics as if People Mattered, E. F. Schumacher, 1973, Blond & Briggs, UK 10. Slow is Beautiful, Cecile Andrews http://www.newsociety.com/Books/S/Slow- is-Beautiful) 11. Science & Humanism – towards a unified worldview, P. L. Dhar & R. R. Gaur (1990), Commonwealth Publishers, New Delhi 12. Sanchian Sri Guru Granth Sahib Ji ,Shiromani GurdwaraParbhandhak Committee, 2001 13. SamanSuttam, JinendraVarni ,1974. 14. Vyavaharvadi Samajshastra, A. Nagraj, Divya Path Sansthan, Amarkantak, India 15. Vyavahatmak Janvad, A. Nagraj, Divya Path Sansthan, Amarkantak, India.
7th	IPA & Waste Management	UNIT I Introduction: Industrial Pollution and types of pollution from chemical process industries, Characterization of emission and effluents, Global consideration of

		environmental pollution, Environmental legislation - Water Act 1974, Air Act 1981, Environmental Protection Act 1986;Standards for liquid effluents from chemical process industries, air quality, nuclear radiationemission, noise emission. UNIT II Pollution Prevention: Process modification, Alternative raw material, Recovery of by productfrom industrial emission/effluents, Recycle and reuse of waste, Energy recovery and wasteutilization, Material and energy balance for pollution minimization, Water minimization,Fugitive emission/effluents and leakages and their control-housekeeping and maintenance. UNIT III Air Pollution Control: Air pollutants classification, Equipments for controlling particulate andgaseous pollutants, lapse rate, atmospheric stability, Dispersion models, Plume behavior, Stackdesign, Design of gravity settling chamber, cyclones, electrostatic precipitator, fabric filters andabsorbers, Air pollution control for petroleum refineries and cement plants. UNIT IV Water Pollution Control: Waste water characteristics, Primary, secondary and tertiary treatments for wastewater, Anaerobic and aerobic treatment biochemical kinetics, Design of trickling filter, activated sludge systems, ponds and lagoons and aeration systems, Water pollution control for petroleum refineries, fertilizer industry, pulp and paper industry. UNIT V Solid Waste Management: Characterization of solid wastes-hazardous and non-hazardous wastes, Waste disposal and management laws and guidelines, Non-hazardous industrial wastestreatment,disposal, utilization and management, Value-extraction from the wastes, Handling,storage and disposal of hazardous wastes, Waste disposal for nuclear power plants. BOOKS: 1. Metcalf & Eddy, “Wastewater Engineering - Treatment and Reuse”, Revised by G. Tchobanoglous, F. L. Burton, and H. D. Stensel, 4th edition. Tata McGraw-Hill, 2003.

		2. Mahajan S. P., Pollution control in process industries, Tata McGraw-Hill, 1985 3. Peavy H.S., Rowe D.R. and Tchobanoglous G., Environmental Engineering, McGraw- Hill edition, 1985 4. Kreith F. and Tchobanoglous G., "Handbook of Solid Waste Management", 2nd Ed., Mc Graw Hill, 2002 5. Pichtel J., "Waste Management Practices: Municipal, Hazardous and Industrial", CRC, 2005
7th	Energy Engg. & Management	UNIT I Energy Scenario: Indian and global, energy crisis, Classification of various energy sources, Renewable and non-renewable energy sources, Remedial measures to some energy crisis. Energy Conservation. UNIT II Alternative Sources of Energy : Fuel cell ,Solar Energy : Photo thermal and photovoltaic conversion and utilization methods , solar water heating , cooking , drying and its use for otherindustrial processes ,solar cells their material and mode of operation . direct and indirect methodssolar energystorage , sensible heat and latent heat storage materials Solar ponds .Bio energy,Biogas plants and their operation , Biomass and its conversion roots to gaseous and liquid fuels, Wind energy , its potential and generation by wind mills. UNIT III Hydroelectric potential, its utilization & production, Geothermal energy its potential status andproduction, Nuclear energy : Status, nuclear raw materials, nuclear reactors and otherclassification, Generation of Nuclear power, Nuclear installations in India and their capacity ofgeneration, Limitations of nuclear energy, Reprocessing of spent nuclear fuel, Cogeneration offuel and power, Energy from tidal and ocean thermal sources, MHD systems. UNIT IV Fossil and Processed Fuel: Coal its origin and formation, Coal analysis, Coal classification, Coal preparation, Coal washing and coal blending, Coal carbonization, Treatment of coal gas andrecovery of chemical from coal tar, Coal gasification, liquid fuel synthesis from coal, CBM. UNIT V

		Petroleum crude , Types of crude ,emergence of petroleum products as energy, GaseousFuels: Natural gas, Water gas, producer gas, L.P.G., bio- gas, coke oven gas, blast furnace gas, LNG,CNG,Gas hydrates ,GTL Technology (gas to liquid), Bio-diesel. BOOKS: 1. Brame J.S.S. and King J.G., Edward Arnold "Fuel Solid, Liquid and Gases" Edward Arnold (1967). 2. Sukhatme S.P, "Solar Energy - Principles of Thermal Collection and Storage",2nd Ed., Tata McGraw- Hill.,(1996).
7th	Process Modeling & Simulation	UNIT I Introduction to mathematical modeling; Advantages and limitations of models and applications of process models of stand-alone unit operations and unit processes; Classification of models: Linear vs. Nonlinear, Lumped parameter vs. Distributed parameter; Static vs. Dynamic, Continuous vs. Discrete; Numerical Methods: Iterative convergence methods, Numerical integration of ODE- IVP and ODE- BVP. UNIT II Concept of degree of freedom analysis: System and its subsystem, System interaction, Degree of freedom in a system e.g. Heat exchanger, Equilibrium still, Reversal of information flow, Design variable selection algorithm, Information flow through subsystems, Structural effects of design variable selection, Persistent Recycle. UNIT III Simple examples of process models; Models giving rise to nonlinear algebraic equation (NAE) systems, - steady state models of flash vessels, equilibrium staged processes distillation columns, absorbers, strippers, CSTR, heat exchangers, etc.; Review of solution procedures and available numerical software libraries. UNIT IV Steady state models giving rise to differential algebraic equation (DAE) systems; Rate based approaches for staged processes; Modeling of differential contactors – distributed parameter models of packed beds;

		Packed bed reactors; Modeling of reactive separation processes; Review of solution strategies for Differential Algebraic Equations (DAEs), Partial Differential Equations (PDEs), and available numerical software libraries. Introduction to unsteady state models and their applications. UNIT V Simulation and their approaches, Modular, Sequential, Simultaneous and Equation solving approach, Simulation softwares and their applications, Review of solution techniques and available numerical software libraries. Review of thermodynamic procedures and physical property data banks. BOOKS: Luyben W.L., "Process Modeling, Simulation, and Control for Chemical Engineering", Mc Graw Hill. D. F. Rudd and C. C. Watson, " Strategy of Process Engineering", Wiley international. M.M. Denn, "Process Modelling", Wiley, New York, (1990). A. K. Jana, "Chemical Process Modelling and Computer Simulation", PHI,(2011) C.D. Holland, "Fundamentals of Modelling Separation Processes", Prentice Hall, (1975) Hussain Asghar, "Chemical Process Simulation", Wiley Eastern Ltd., New Delhi, (1986)
7th	Process Design & Economics	UNIT-I Introduction , Basic design procedure and theory , Heat exchanger analysis: the effectiveness NTU method , Overallheat-transfer coefficient , Fouling factors (dirt factors) ,Shell and tube exchangers: construction details , Heat exchangerstandards and codes ,Tubes , Shells , Tube-sheet layout (tube count) ,Shell types (passes) , Shell and tubedesignation ,Baffles , Support plates and tie rods , Tube sheets (plates) ,Shell and header nozzles (branches) ,Flow inducedtube vibrations ,Mean temperature difference (temperature driving force) , Shell and tube exchangers:general design considerations , Fluid allocation: shell or tubes ,Shell and tube fluid velocities ,Stream temperatures , Pressure drop, Fluid physical properties ,Tube-side heat-transfer coefficient and pressure

		drop (single phase) ,Heat transfer , Tube-side pressure drop ,Shell-side heat-transfer and pressure drop (single phase) ,Flow pattern , Design methods ,Kern's method ,Bell's method , Shell and bundle geometry ,Effect of fouling on pressure drop , Pressure droplimitations. UNIT –II Condensers ,Heat-transfer fundamentals , Condensation outside horizontal tubes ,Condensation inside and outside vertical tubes , Condensation inside horizontal tubes , Condensation of steam , Mean temperature difference , Desuperheating and sub-cooling Condensation of mixtures Pressure drop in condensers , Design of forced circulation reboilers , Design of thermosyphon reboilers ,Design of kettle reboilers , Heat transfer to vessels Jacketed vessels , Internal coils , Agitated vessels . UNIT –III Design methods for binary distillation systems , Basic equations , McCabe-Thiele method ,Low product concentrations , The Smoker equations ,Batch distillation , Steam distillation, Plate efficiency, Prediction of plate efficiency :O'Connell's correlation , Van Winkle's correlation , AIChE method , Entrainment , Approximate column sizing , Plate contactors , Selection of plate type , Plate construction , Plate hydraulic design,Plate-design procedure, Plate areas ,Diameter , Liquid-flow arrangement ,Entrainment ,Weep point , Weir liquid crest , Weir dimensions , Perforated area , Hole size , Hole pitch ,Hydraulic gradient ,Liquid throw , Plate pressure drop , Downcomer design UNIT–IV Design of packed columns for absorption/stripping, Types of packing, Packed-bed height- Prediction of the height of a transfer unit (HTU), Prediction of the number of transfer units (NTU), Column diameter (capacity) , Column internals , Wetting rates , Column auxiliaries UNIT –V Analysis of Cost Estimates: Factors affecting investment and production costs, Capital investment, Types of capital cost estimates, Methods for estimating capital investment, Estimation of Revenue, Estimation of total product cost, Gross Profit, Net Profit and Cash flow Simple and Compound interest, Loan Payments, Cash flow pattern –Discrete cash flow &

		Continuous cash flow, Profitability, Alternative investments by different profitability methods, Effect of inflation on profitability analysis, Methods of profitability evaluation for replacements. Depreciation: Straight line, Declining balance, Double declining balance, sum-of-the-digit, Sinking-fund, Accelerated cost recovery system, Modified accelerated cost recovery system. BOOKS: Towler G. and Sinnott R. K., "Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design", Butterworth-Heinemann.2008 Seader J. D. and Henley E. J., "Separation Process Principles", 2nd Ed., Wiley-India.2006 I.S.: 4503-1967, "Indian Standard Specification for Shell and Tube Type Heat Exchangers", Bureau of Indian Standards.2007 Hewitt G. F., Shires G. L. and Bott T. R., "Process Heat Transfer", CRC Press.1994 Serth R.W., "Process Heat Transfer: Principles and Applications", Academic Press.2007 Coker A. K., "Ludwig's Applied Process Design for Chemical and Petrochemical Plants", Vol. 1, 4th Ed., Gulf Publishers.2007 Ludwig E. E., "Applied Process Design for Chemical and Petrochemical Plants", Vol. 2, 3rd Ed., Gulf Publishers.1997 Ludwig E. E., "Applied Process Design for Chemical and Petrochemical Plants", Vol. 3, 3rd Ed., Gulf Publishers. Peters M. S. and Timmerhaus K. D., "Plant Design And Economics For Chemical Engineers", 5th Ed., McGraw Hill, International Ed.2004
8th	Renewable Energy Resources	UNIT-I Introduction: Various non-conventional energy resources- Introduction, availability, classification, relative merits and demerits. Solar Cells: Theory of solar cells. Solar cell materials, solar cell array, solar cell power plant, limitations. UNIT-II

		Solar Thermal Energy: Solar radiation, flat plate collectors and their materials, applications and performance, focussing of collectors and their materials, applications and performance; solar thermal power plants, thermal energy storage for solar heating and cooling, limitations. UNIT-III Geothermal Energy: Resources of geothermal energy, thermodynamics of geothermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations. Magneto-hydrodynamics (MHD): Principle of working of MHD Power plant, performance and limitations.Fuel Cells: Principle of working of various types of fuel cells and their working, performance and limitations. UNIT-IV Thermo-electrical and thermionic Conversions: Principle of working, performance and limitations. Wind Energy: Wind power and its sources, site selection, criterion, momentum theory, classification of rotors, concentrations and augments, wind characteristics. performance and limitations of energy conversion systems. UNIT-V Bio-mass:Availability of bio-mass and its conversion theory. Ocean Thermal Energy Conversion (OTEC): Availability, theory and working principle, performance and limitations. Wave and Tidal Wave: Principle of working, performance and limitations. Waste Recycling Plants. Text books: 1. Raja etal, “Introduction to Non-Conventional Energy Resources” Scitech Publications. 2. John Twideu and Tony Weir, “Renewal Energy Resources” BSP Publications, 2006. 3. M.V.R. Koteswara Rao, “Energy Resources: Conventional & Non-Conventional” BSP Publications,2006. 4. D.S. Chauhan,”Non-conventional Energy Resources” New Age International. 5. C.S. Solanki, “Renewal Energy Technologies: A Practical Guide for Beginners” PHI Learning.

		6. Peter Auer, "Advances in Energy System and Technology". Vol. 1 & II Edited by Academic Press. 7. Godfrey Boyle,“ Renewable Energy Power For A Sustainable Future”, Oxford University Press.
8th	Fertilizer Technology	Unit 1 Introduction of Indian fertilizer industries, types of fertilizers process details. Unit 2 Manufacture of Nitrogenous, Phosphatic, potassic, complex, NPK, mixed, Bio and other fertilizers. Unit 3 Discussion of existing Indian plants pollution and its control, abetment and disposal of waste of fertilizer units. Unit 4 Retrofits and modernization, computer control and Instrumentation, Energy conservation and diversification. Unit 5 Design of ammonia converters and other reactors, colling water, expansion, capacity utilization and other problem of fertilizers industry.
8th	Petrochemical Technology	Unit 1 Production and consumption pattern of petrochemicals in India, Feedstocks for petrochemicals-Natural gas, LPG, Refinery off-gases, Hydroforming of petroleum stocks, Naphtha and fuel oils, Petroleum coke. Unit 2 Steam reforming and partial oxidation processes for syngas, Manufacture of Methanol, Formaldehyde, Chloromethanes, Trichloroethylene, Perchloroethylene, Acetic acid, adipic acid. Unit 3 Ethylene and acetylene via steam cracking of hydrocarbons, Manufacture of Ethylene dichloride, Vinyl chloride, Ethylene oxide, Ethanolamine, Acetaldehyde, Vinyl acetate, Ethylene glycol. Unit 4 Manufacture of Isopronol, Acetone, Methyl ethyl ketone, Methyl isobutyl ketone, Cumene, Acrylonitrile, Propylene oxide, Butadiene, Oxo process

		Unit 5 Manufacture of Benzene, Toluene, Xylenes, Phenol, Styrene, Phthalic anhydride, Maleic anhydride, Nitrobenzene, Aniline, Bisphenol-A, Caprolactum.