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 : 2020-2021

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 advancingcontributions 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

Sl. No.	Subject Codes	Subject	Periods			Evaluation Scheme				End Semester		Total	Credit
			L	T	P	CT	TA	Total	PS	TE	PE		
1	BT-***	Engineering Science and Engineering	3	1	0	30	20	50		100		150	4
2	BT-***	Universal Human values	2 3	1 0	0 0	30	20	50		100		150	3
3	BT-***	Material and Energy Balance	3	1	0	30	20	50		100		150	4
4	BT-***	Chemical Engineering FluidMechanics	3	1	0	30	20	50		100		150	4
5	BT-***	Heat Transfer Operations	3	0	0	30	20	50		100		150	3
6	BT-***	Chemical Engineering FluidMechanics Lab	0	0	2				25		25	50	1
7	BT-***	Heat Transfer Operations Lab	0	0	2				25		25	50	1
8	BT-***	Soft Computing Lab	0	0	2				25		25	50	1
9	BT-***	Mini Project or Internship Assessment*	0	0	2			50				50	1
10	BT-***	Computer Security system	2	0	0	15	10	25		50			0
11		MOOCs (Essential for Hons.Degree)											
		Total										**950**	**22**

***The Mini Project or internship (3-4 weeks) conducted during summer break after II semester and will be assessed during IIIsemester.

B.TECH II YEAR IV SEMESTER
CHEMICAL ENGINEERING

SEMESTER- IV													
Sl. No.	**Subject Codes**	**Subject**	**Periods**			**Evaluation Scheme**				**End Semester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	BT-***	Maths IV	3	1	0	30	20	50		100		150	4
2	BT BT	Technical Communication	3 2	0 1	0 0	30	20	50		100		150	3
3	BT	Mechanical Operations	3	0	0	30	20	50		100		150	3
4	BT	Chemical Reaction Engineering-I	3	1	0	30	20	50		100		150	4
5	BT	Chemical Engineering Thermodynamics	3	1	0	30	20	50		100		150	4
6	BT	Mechanical Operations Lab	0	0	2				25		25	50	1
7	BT	Chemical Reaction Engineering Lab	0	0	2				25		25	50	1
8	BT	Numerical Methods of Analysis Lab	0	0	2				25		25	50	1
9	BT	Python Programming	2	0	0	15	10	25		50			0
10		MOOCs (Essential for Hons. Degree)											
		Total										**900**	**21**

B.TECH III YEAR V SEMESTER
CHEMICAL ENGINEERING

SEMESTER- V													
Sl. No	**Subject Codes**	**Subject**	**Periods**			**Evaluation Scheme**				**End Semester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	BT-***	Mass Transfer -I	3	1	0	30	20	50		100		150	4
2	BT-***	Chemical Reaction Engineering – II	3	1	0	30	20	50		100		150	4
3	BT-***	Process Dynamics andControl	3	1	0	30	20	50		100		150	4
4	BT-***	Optimization Techniques	3	0	0	30	20	50		100		150	3
5	BT-***	Intellectual Property Rights & Standardization	3	0	0	30	20	50		100		150	3
6	BT-***	Mass Transfer-I Lab	0	0	2				25		25	50	1
7	BT-***	PDC Lab	0	0	2				25		25	50	1
8	BT-***	Process Modelling andSimulation Lab	0	0	2				25		25	50	1
9		Mini Project or Internship Assessment*	0	0	2				50			50	1
10	NC	Constitution of India	2	0	0	15	10	25		50			
11		MOOCs (Essential for Hons. Degree)											
		Total	**17**	**3**	**8**							**950**	**22**

***The Mini Project or internship (4 weeks) conducted during summer break after IV semester and will be assessed during Vsemester.

B.TECH III YEAR VI SEMESTER
CHEMICAL ENGINEERING

SEMESTER- VI													
Sl. No	**Subject Codes**	**Subject**	**Periods**			**Evaluation Scheme**				**End Semester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	BT-***	Mass Transfer -II	3	1	0	30	20	50		100		150	4
2	BT-***	Transport Phenomenon	3	1	0	30	20	50		100		150	4
3	BT-***	Chemical Technology	3	1	0	30	20	50		100		150	4
4	BT-***	Sustainability of Environment	3	0	0	30	20	50		100		150	3
5		Understanding the human being comprehensively	3	0	0	30	20	50		100		150	3
6	BT-***	Chemical Technology Lab	0	0	2				25		25	50	1
7	BT-***	Mass Transfer-II Lab	0	0	2				25		25	50	1
8	BT-***	Technical Presentation	0	0	2				25		25	50	1
9	NC	Essence of Indian Traditional Knowledge	2	0	0	15	10	25		50			
10		MOOCs (Essential for Hons. Degree)											
		Total	**0**	**3**	**6**							**900**	**21**

B Tech. Chemical Engineering

4th Year VII-SEMESTER **Session- 2020-21**

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- 2020-21**

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	**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	**Chemical 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	**Heat Transfer Operation**	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.
3rd	**Energy Science and Engineering**	After studying this subject students will be able to: CO1. Have basic understanding of the energy sources and scientific concepts/principles behind them CO2. Understand effect of using these sources on the environment and climate CO3. Describe the challenges and problems associated with the use of various energy sources, including fossil fuels, with regard to future supply and the impact on the environment. CO4. List and describe the primary renewable energy resources and technologies. CO5. To quantify energy demands and make comparisons among energy uses, resources, and technologies. CO6. Collect and organize information on renewable energy technologies as a basis for further analysis and evaluation. CO7. Understand the Engineering involved in projects utilizing these sources.
3rd	**Computer Security System**	After successful completion of course the students should be able to CO1. Formulate information security governance, and related legal and regulatory issues. CO2. Devices how threats to an organization are discovered, analyzed, and dealt with. CO3. Evaluate network security threats andcounter measures.

		CO4. Construct network security designs using available secure solutions (such as PGP, SSL, IPSec, etc) CO5. Acquire the knowledge of advanced security issues and technologies (such as attack detection and containment and anonymous communications). CO6. Understand how cyber security is going to help the implications of cybercrime. 7. Illustrate various aspects of Cyber security, Cyber crimes and its related laws in Indian and Global Act.
3rd	**Universal Human Value**	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	**Chemical 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	**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.
4th	**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
4th	**Python Programming**	After completion of this course, student will be able to: CO1. Interpret the fundamental Python syntax and semantics and be fluent in the use of Python control flow statements. CO2. Express proficiency in the handling of strings and functions.

		CO3. Determine the methods to create and manipulate Python programs by utilizing the data structures like lists, dictionaries, tuples and sets. CO4. Identify the commonly used operations involving file systems and regular expressions. CO5. Articulate the Object-Oriented Programming concepts such as encapsulation, inheritance and polymorphism as used in Python.
5th	**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.
5th	**Optimization Technique**	After completion of this course, student will be able to: CO1.Identify different types of optimization problems CO2.Understanding of different optimization technique CO3.Ability to solve various multivariable optimization problems CO4.Ability to solve optimization using software tools. CO5.Identify different types of test of Hypotheses.

		CO6.Ability to solve problems by using least square analysis. CO7.Understand Correlation and Regression
5th	**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.
5th	**Intellectual Property Rights**	Upon completion of this course, the students will be able to: CO1.The students once they complete their academic projects, shall get an adequate knowledge on patent and copyright for their innovative research works CO2.During their research career, information in patent documents provide useful insight on novelty

		of their idea from state-of-the art search. This provide further way for developing their idea or innovations CO3.Proved the way for the students to catch up Intellectual Property(IP) as an career option CO4.Gives awareness of international standards to students
5th	**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	**Chemical Technology**	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.
6th	**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
6th	**Mass Transfer -2**	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	**Sustainability of Environment**	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
7th	**Process Design & Economics**	On completion of this course, the students will be able to CO1. To learn basic economic concept, to understand and apply this concepts in the project works undertaken and to chemical engineering situation by solving problem CO2. Carry out the primary techno-economic feasibility of project. CO3. Select appropriate process for a project. CO4. Differentiate the equipment and able to prepare specification sheet CO5. Understand piping and instrumentation diagram CO6. Evaluate the project cost including capital investment, product cost, breakeven point, depreciation cost for equipment and the total project cost.

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.

Syllabus

Semester	Course Code	Course Title	Syllabus
3rd		Material and Energy Balance	Unit-1 Introduction: Units and dimension in chemical engineering, units conversion of dimensional equations, stoichiometric and composition relations, concept of degrees of freedom and linear independence of a set of equations.

			Material Balance: Concept of material balance, open and closed systems, steady state and unsteady state, multiple component system, selection of a basis, problem solving strategy. Unit-2 Material Balance without Chemical Reaction for Single and Multiple Units: Conservation of mass/atom, material balance for Systems without chemical reactions involving single unit and multiple unit Material Balance with Chemical Reaction for Single and Multiple Units: Concept of excess reactant, extent of reaction, Material balance for systems with chemical reactions involving single unit and multiple units. Unit-3 Recycle, Bypass, Purge and Industrial Applications: Calculations for a cyclic processes involving recycle/ purge/ bypass, material balances involving gases, vapors, liquids and solids and use of real gas relationships, material balance involving gases, vapors, liquids & solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of humidity & saturation, analysis of systems with bypass, recycle and purge, analysis of processes involving condensation, crystallization and vaporization. Unit-4 Energy Balance: Conservation of energy with reference to general energy balance with and without chemical reactions, chemical engineering problems involving reversible processes and mechanical energy balance. Applications of Energy Balance: Calculations of heat of change of phase (solid – liquid & liqid – vapor), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and nonadiabatic reactions, use of psychometric and enthalpyconcentration diagrams. Unit-5

			Simultaneous Material and Energy Balances: Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems. Unsteady State Material and Energy Balances: Transient materials and energy balances involving with and without chemical reactions. REFERENCE BOOKS: S. No. Name of Authors / Books / Publishers Year of Publication/ Reprint 1. Himmelblau D.M. and Riggs J. B.," Principles and Calculations in Chemical Engineering", 8th Ed., Prentice Hall of India. 2012 2. Felder R.M. and Rousseau R.W., "Elementary Principles of Chemical Processes", 3rd Ed.., John Wiley. 2005 3. Bhatt B.I. and Vora S.M., "Stoichiometry", 5th Ed., Tata McGraw-Hill 2010 4. Narayanan K.V. and Lakshmikutty B., "Stoichiometry and Process Calculations", Prentice Hall of India. 2006 5. Hougen D.A., Watson K.M. and Ragatz R.A., "Chemical Process Principles", Part-I, 2nd Ed., CBS Publishers. 1995
3rd		Chemical Engineering Fluid Mechanics	Unit-1 Introduction: Fundamental concepts of fluids; Fluid statics, kinematics and dynamics; Properties of fluids. Fluid Statics: The basic equation of fluid statics; Pressure – depth relationship; Pressure forces on plane and curved surfaces; Buoyancy and stability; Forces on immersed and submerged bodies; Pressure measurements; Pressure in accelerated rigid body motions. Unit-2 Elementary Fluid Kinematics: Lagrangian and Eulerian descriptions; Flow visualization – streamline, pathline, streakline and timeline, profile plots; Description and classification of fluid

			motions; Rotational, irrotational, inviscid and potential flows; Deformation of fluids; System and control volume representation; Reynolds transport theorem. Unit-3 Dynamic Analysis of Flow: Conservation of mass, linear and angular momentum, and energy; Eulers equation of motion, Bernoulli theorem; Navier-Stokes equations. Dimensional Analysis, Similitude and Modeling: Dimensional homogeneity and analysis; Methods of finding dimensionless numbers; Selection of variables, Rayleigh and Buckingham's π method; Common dimensionless numbers and their physical significance; Model and Prototypes; Complete and incomplete similarity. Unit-4 Internal Incompressible Viscous Flow: General characteristics of pipe flow – laminar, turbulent, entrance region, fully developed; Fully developed laminar/turbulent flow in pipe – shear stress distribution and velocity profiles; Energy correction factors; Energy and hydraulic grade lines; Major and minor losses in pipes, fittings, pipe network; Friction factor. Flow Measurements: Flow rate and velocity measurements – Pitot tube, orifice meter, venturimeter, rotameter, notches and weirs. Unit-5 Fluid Handling Machinery: Classification; Positivedisplacement pumps and compressors, centrifugal pumps and compressors, Axial flow pumps and compressors, compressor efficiency. Characteristics of centrifugal pumps; NPSH; Selection of pumps Agitation and Mixing: Agitated vessels; Blending and mixing; Suspension of solid particles; Dispersion operations; Agitator selection and scale up.

			REFERENCE BOOKS: S. No. Name of Authors / Books / Publishers Year of Publication/ Reprint 1. Nevers N.D., "Fluid Mechanics For Chemical Engineers", 3rd Ed., McGraw Hill Higher Education. 2005 2. Cengel Y.A. and Cimbala J.M. "Fluid Mechanics: Fundamentals and Applications", 2nd Ed. McGraw-Hill 2010 3. Balachandran P. "Engineering Fluid Mechanics", PHI Learning Pvt Ltd., New Delhi 2012 4. Munson B.R., Young D.F., Okiishi T.H. and Huebsch W.W., "Fundamentals of Fluid Mechanics", 6th Ed., Willey 2010 5. White F.M. "Fluid Mechanics", 7th Ed. Tata McGraw-Hill 2010 6. Rajput, R. K., "Textbook of Fluid Mechanics", S. Chand and Co., New Delhi. 1998
3rd		Heat Transfer Operation	Unit-1 Introduction: Importance of heat transfer in Chemical Engineering operations - Modes of heat transfer. Conduction: Fourier's law of heat conduction; One dimensional steady state heat conduction equation for flat plate; Hollow cylinder - Heat conduction through a series of resistances; Thermal conductivity measurement; Effect of temperature on thermal conductivity; Heat transfer in extended surfaces; Numerical Methods for solving conduction heat transfer problem (Explicit and Implicit methods); Stability criteria. Unit-2 Convection: Concepts of heat transfer by convection; Natural and forced convection; Analogies between transfer of momentum and heat; Reynold's analogy; Prandtl and Coulburn analogy. Dimensional analysis; Correlations for the calculation of heat transfer coefficients; Heat transfer coefficient for flow through a pipe; Flow through non circular conduit; Flow past flat plate; Extended surface. Lumped system analysis; Heat transfer augmentations.

			Unit-3 Radiation: Heat transfer by radiation; Emissive power; Black body radiation; Emissivity, Kirchhoff's law; Stefan - Boltzmann law; Plank's law; Radiation between surfaces. Evaporator: Classification and use of evaporators in process industries, effect of boiling point rise on evaporator performance, Single effect and multiple effect evaporation - Design calculation for single and multiple effect evaporation. Unit-4 Boiling: Characteristics, nucleate pool- and forced convection-boiling, boiling mechanism and curve, heat transfer correlations, heat pipes. Condensation: Mechanism and types of condensation of vapor; Drop wise and film wise condensation; Nusselt equation for vertical and horizontal tubes; Condensation of superheated vapours; Effect of non-condensable gasses on rate of condensation. Unit-5 Heat Exchangers: Parallel and counter flow heat exchangers; Log mean temperature difference; Single passand multi pass heat exchangers; Double pipe; Shell and tube; Plate and frame heat exchangers; use of correction factor charts; Heatexchangers effectiveness; Number of transfer unit; Chart for different configurations;Fouling factors; Design of heat exchangers; Selection criteria and application of Heat exchanger; Introduction to TEMA type heat transfer and applications. REFERENCE BOOKS: S. No. Name of Authors / Books / Publishers Year of Publication/ Reprint 1. Holman, J. P., Heat Transfer, 10th Edition., Tata McGraw-Hill Education Private ltd. 2011 2. Kern, D.Q., Process Heat Transfer, 1st Edition, Tata McGrawHill Education Private ltd. 2001

			3. Cengel Y.A. and Ghajar A.J., "Heat and Mass Transfer: Fundamentals and Applications", 4th Ed., McGraw Hill 2010 4. McCabe, W.L, Smith J.C, and Harriot, P, Unit Operations in Chemical Engineering, 7th Edition, McGraw-Hill, Inc. 2004 5. Coulson, J.M. and Richardson, J.F, Chemical Engineering, Vol. I, 6th Edition, Elsevier India. 1999
3rd		Energy Science and Engineering	Unit-I Energy and its Usage: Units and scales of energy use, Mechanical energy and transport, Heat energy: Conversion between heat and mechanical energy, Electromagnetic energy: Storage, conversion, transmission and radiation, Introduction to the quantum, energy quantization, Energy in chemical systems and processes, flow of CO2, Entropy and temperature, carnot and Stirling heat engines, Phase change energy conversion, refrigeration and heat pumps, Internal combustion engines, Steam and gas power cycles, the physics of power plants. Solid-state phenomena including photo, thermal and electrical aspects Unit-II Nuclear Energy: Fundamental forces in the universe, Quantum mechanics relevant for nuclear physics, Nuclear forces, energy scales and structure, Nuclear binding energy systematics, reactions and decays, Nuclear fusion, Nuclear fission and fission reactor physics, Nuclear fission reactor design, safety, operation and fuel cycles Unit-III Solar Energy: Introduction to solar energy, fundamentals of solar radiation and its measurement aspects, Basic physics of semiconductors, Carrier transport, generation and recombination in semiconductors, Semiconductor junctions: metal-semiconductor junction & p-n junction, Essential characteristics of solar photovoltaic devices, First Generation Solar Cells, Second Generation Solar Cells, Third Generation Solar Cells Unit-IV Conventional & non-conventional energy source: Biological energy sources and fossil fuels, Fluid dynamics and

			power in the wind, available resources, fluids, viscosity, types of fluid flow, lift, Wind turbine dynamics and design, wind farms, Geothermal power and ocean thermal energy conversion, Tidal/wave/hydro power Unit-V Systems and Synthesis: Overview of World Energy Scenario, Nuclear radiation, fuel cycles, waste and proliferation, Climate change, Energy storage, Energy conservation. Engineering for Energy conservation: Concept of Green Building and Green Architecture; Green building concepts, LEED ratings; Identification of energy related enterprises that represent the breath of the industry and prioritizing these as candidates; Embodied energy analysis and use as a tool for measuring sustainability. Energy Audit of Facilities and optimization of energy consumption Reference/Text Books 1. Energy and the Challenge of Sustainability, World Energy Assessment, UNDP, New York, (2000). 2. Perspective of Modern Physics, A. Beiser, McGraw-Hill International Editions (1968). 3. Introduction to Modern Physics, H.S. Mani and G.K.Mehta, East-West Press (1988). 4. Introduction to Electrodynamics, D. J. Griffiths, Fourth Edition, Prentice Hall (2013). 5. Introductory Nuclear Physics, R. K. Puri and V.K. Babbar, Narosa Publishing House (1996). 6. Physics of Solar Cells: From Basic Principles to Advanced Concepts by Peter Wurfel, John Wiley & Sons, 2016 7. Principles of Solar Engineering, D.Y. Goswami, F.Kreith and J.F. Kreider, Taylor and Francis, Philadelphia, 2000
3rd		Universal Human Value	Unit-1 Course Introduction - Need, Basic Guidelines, Content and Process for Value Education Understanding the need, basic guidelines, content and process for Value Education, Self-

			Exploration–what is it? - its content and process; 'Natural Acceptance' and Experiential Validation- as the mechanism for self exploration, Continuous Happiness and Prosperity- A look at basic Human Aspirations, Right understanding, Relationship and Physical Facilities- the basic requirements for fulfillment of aspirations of every human being with their correct priority, Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfill the above human aspirations: understanding and living in harmony at various levels. Unit-2 Understanding Harmony in the Human Being - Harmony in Myself Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya Unit-3 Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship Understanding harmony in the Family- the basic unit of human interaction , Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay-tripti; Trust (Vishwas) and Respect (Samman) as the foundational values of relationship, Understanding the meaning of Vishwas; Difference between intention and competence, Understanding the meaning of Samman, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Samadhan,

			Samridhi, Abhay, Sah-astitva as comprehensive Human Goals, Visualizing a universal harmonious order in societyUndivided Society (AkhandSamaj), Universal Order (SarvabhaumVyawastha)- from family to world family!. Unit-4 Understanding Harmony in the Nature and Existence - Whole existence as Co-existence Understanding the harmony in the Nature, Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature, Understanding Existence as Co-existence (Sah-astitva) of mutually interacting units in all-pervasive space, Holistic perception of harmony at all levels of existence. Unit-5 Implications of the above Holistic Understanding of Harmony on Professional Ethics Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in Professional Ethics: a) Ability to utilize the professional competence for augmenting universal human order, b) Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, technologies and management models, Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a) At the level of individual: as socially and ecologically responsible engineers, technologists and managers, b) At the level of society: as mutually enriching institutions and organizations. Text Books: 1. R R Gaur, R Sangal, G P Bagaria, 2009, A Foundation Course in Human Values and Professional Ethics References: 1. Ivan Illich, 1974, Energy & Equity, The Trinity Press, Worcester, and Harper Collins, USA

			2. E.F. Schumacher, 1973, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain. 3. Sussan George, 1976, How the Other Half Dies, Penguin Press. Reprinted 1986, 1991
4th		Chemical Engineering Thermodynamics	Unit-1 Thermodynamic Laws and Property Relations: Laws of thermodynamics and their applications; PVT behaviour of pure substances; PVT behaviour of mixtures; Generalized equations of state;Joule's experiment; Carnot cycle and Carnot theorems; Thermodynamic property relations; Maxwell relations; Partial derivatives and Jacobian method; Residual properties; Partial molar properties; Excess properties of mixtures; Thermodynamic property tables and diagrams, Unit-2 Properties of Solutions and Phase Equilibria: Criteria for equilibrium between phases in multi component non-reacting systems in terms of chemical potential and fugacity; Application of phase rule; Vapour-liquid equilibrium; Phase diagrams for homogeneous systems and for systems with a miscibility gap; Effect of temperature and pressure on azeotrope composition; Liquid-liquid equilibrium; Ternary liquid liquid equilibrium. Unit-3 Correlation and Prediction of Phase Equilibria: Activity coefficient; Composition models; thermodynamic consistency of phase equilibria; Application of the correlation and prediction of phase equilibria in systems of engineering interest particularly to distillation and liquid extraction processes. Unit-4 Chemical Reaction Equilibria: Definition of standard state; standard free energy change and reaction equilibrium constant; evaluation of reaction equilibrium constant; prediction of free energy data; equilibria in chemical reactors, calculation of

			equilibrium compositions for homogeneous chemical reactors; thermodynamic analysis of simultaneous reactions. Unit-5 Refrigeration: Principles of refrigeration; methods of producing refrigeration; liquefaction process; coefficient of performance; evaluation of the performance of vapour compression and gas refrigeration cycles. REFERENCE BOOKS: S. No. Name of Authors / Books / Publishers Year of Publication/ Reprint 1. Smith, J.M., VanNess, H.C., & Abbot M.C, Introduction to Chemical Engineering Thermodynamics, 7th Edition, Tata Mcgraw Hill Education Private Limited. 2009 2. Narayanan K.V, Text Book of Chemical Engineering Thermodynamics, Phi Learning Pvt. Ltd-New Delhi. 2013 3. Hougen, O.A., Watson, K.M., and Ragatz, R.A., Chemical Process Principles Part II", Thermodynamics, John Wiley. 1970 4. Dodge, B.F., Chemical Engineering Thermodynamics,1st Edition, 6th im edition McGraw-Hill,. 1944 5. Sandler, S.I., Chemical,Biochemical and Engineering Thermodynamics, 4th Edition, Wiley. 2006
4th		Chemical Reaction Engineering I	Unit-1 Rate Equations: Rate equation – elementary - non-elementary reactions - theories of reaction rate and temperature dependency - Design equation for constant and variable volume batch reactors - analysis of experimental kinetics data - integral and differential analysis. Unit-2 Design of Reactors: Design of continuous reactors - stirred tank and tubular flow reactor, recycle reactors - combination of reactors - size comparison of reactors. Unit-3

			Design of Multiple Reactors: Design of reactors for multiple reactions – consecutive - parallel and mixed reactions – factors affecting choice - optimum yield and conversion - selectivity, reactivity and yield. Unit-4 Non – isothermal Reactors: Non-isothermal homogeneous reactor systems - adiabatic reactors - rates of heat exchanges for different reactors - design for constant rate input and constant heat transfer coefficient - operation of batch and continuous reactors - optimum temperature progression. Unit-5 Non Ideal Reactors: The residence time distribution as a factor of performance; residence time functions and relationship between them in reactor; basic models for nonideal flow; conversion in non ideal reactors. REFERENCE BOOKS: S. No. Name of Authors / Books / Publishers Year of Publication/ Reprint 1. Levenspiel O, Chemical Reaction Engineering, 3rd Edition, Wiley India Pvt Ltd. 2010 2. Smith, J.M, Chemical Engineering Kinetics, 3rd Edition McGraw. 2014 3. Fogler.H.S., Elements of Chemical Reaction Engineering, 4th Edition, Phi Learning Pvt Ltd (RS). 2009 4. Froment. G.F. & K.B.Bischoff,Chemical Reactor Analysis and Design, 3rd Edition, Wiley. 2010 5. Butt, J.B., " Reaction Kinetics and Reactor Design" 2nd Ed., CRC Press 2000
4th		Mechanical Operation	Unit-1 Particles Size Analysis: General characteristics of solids; Different techniques of size analysis; Shape factor; Surface area determination; Estimation of particle size; Screening methods and equipment; Screen efficiency; Ideal and actual screens.

			Unit-2 Size Reduction: Methods of size reduction; Classification of equipments; Crushers; Grinders; Disintegrators for coarse, Intermediate and fine grinding; Laws of size reduction; Energy relationships in size reduction; power requirement; Work index. Size Enlargement: Principle of granulation; Briquetting; Pelletisation; Flocculation. Unit-3 Particle Separation: Gravity settling; Sedimentation; Thickening; Elutriation; Double cone classifier; Rake classifier; Bowl classifier; Centrifugal separation; Continuous centrifuges; Design of basket centrifuges; Industrial dust removing equipment; Cyclones; Hydro cyclones; Electrostatic - Magnetic separators; Heavy media separations; Floatation; Jigging. Unit-4 Flow through Porous media (Filtration): Theory of filtration,Batch and continuous filters, Filtration equipments; Rotary drum filter; Plate and frame filter; Leaf filter; Notch filter; Sand filter; Bag filter; Selection; Operation; Filter aids. Flow through filter cake and Filter media; Compressible and incompressible filter cakes; Design of filters and optimum cycle of operation. Fluidization: Fluidization characteristics, aggregative and particulate fluidization, voidage and minimum fluidization velocity,terminal velocity of particles; entrainment; pressure drop in fluidization. Unit-5 Mixing and agitation: Mixing of liquids (with or without solids); Mixing of powders; Ribbon blender; Screw blender; Double cone blender; High viscous mixer; Banbury mixer; Selection of suitable mixers; Power requirement for mixing. Storage and conveying of solids: Bunkers; Silos; Bins; Hoppers; Transportation of solids in bulk; Conveyer selection; Types of

			conveyers; Belt Conveyor; Bucket conveyor; Screw conveyor; Pneumatic conveyor; Their performance and characteristics. REFERENCE BOOKS: S. No. Name of Authors / Books / Publishers Year of Publication/ Reprint 1. Backhurst, J. R. and Harker J. H.,"Coulson and Richardson Chemical Engineering", Vol. II",5th Ed., ButterworthHeinemann. 2004 2. McCabe W.L., Smith J.C and Harriott P., "Unit Operations of Chemical Engineering", 7th Ed. , McGraw Hill. 2005 3. Foust, A. S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., Principles of Unit Operations, 2nd Edition., John Wiley & Sons 1980 4. Brown G.G., Unit Operations, CBS Publishers & Distributors 2005 5. Hiramath R.S., Kulkarni A.P., Unit Operations of Chemical Engineering, 9th Edition, Everest Publications 2004 6. Narayanan C.M. & Bhattacharya B.C., "Mechanical Operation for Chemical Engineers –Incorporating Computer Aided Analysis", Khanna Publishers. 1992
4th		Python Programming	Unit-1 Introduction: The Programming Cycle for Python , Python IDE, Interacting with Python Programs , Elements of Python, Type Conversion. Basics: Expressions, Assignment Statement, Arithmetic Operators, Operator Precedence, Boolean Expression. Unit-2 Conditionals: Conditional statement in Python (if-else statement, its working and execution), Nested-if statement and Elif statement in Python, Expression Evaluation & Float Representation. Loops: Purpose and working of loops , While loop including its working, For Loop , Nested Loops , Break and Continue

			Unit-3 Function: Parts of A Function , Execution of A Function , Keyword and Default Arguments ,Scope Rules. Strings: Length of the string and perform Concatenation and Repeat operations in it. Indexing and Slicing of Strings. Python Data Structure : Tuples , Unpacking Sequences , Lists , Mutable Sequences , List Comprehension , Sets , Dictionaries Higher Order Functions: Treat functions as first class Objects , Lambda Expressions Unit-4 Sieve of Eratosthenes: generate prime numbers with the help of an algorithm given by the Greek Mathematician named Eratosthenes, whose algorithm is known as Sieve of Eratosthenes. File I/O : File input and output operations in Python Programming Exceptions and Assertions Modules : Introduction , Importing Modules , Abstract Data Types : Abstract data types and ADT interface in Python Programming. Classes: Class definition and other operations in the classes , Special Methods (such as _init_, _str_, comparison methods and Arithmetic methods etc.) , Class Example , Inheritance , Inheritance and OOP. Unit-5 Iterators & Recursion: Recursive Fibonacci , Tower Of Hanoi Search : Simple Search and Estimating Search Time , Binary Search and Estimating Binary Search Time Sorting & Merging: Selection Sort , Merge List , Merge Sort , Higher Order Sort Text books: 1. Allen B. Downey, ``Think Python: How to Think Like a Computer Scientist‘‘, 2nd edition, Updated for Python 3,

			Shroff/O'Reilly Publishers, 2016 (http://greenteapress.com/wp/thinkpython/) 2. Guido van Rossum and Fred L. Drake Jr, —An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011. 3.John V Guttag, —Introduction to Computation and Programming Using Python'', Revised and expanded Edition, MIT Press , 2013 4.Robert Sedgewick, Kevin Wayne, Robert Dondero, —Introduction to Programming in Python: An Inter-disciplinary Approach, Pearson India Education Services Pvt. Ltd., 2016 5.Timothy A. Budd, —Exploring Python‖, Mc-Graw Hill Education (India) Private Ltd.,, 2015. 6.Kenneth A. Lambert, —Fundamentals of Python: First Programs‖, CENGAGE Learning, 2012. 7.Charles Dierbach, —Introduction to Computer Science using Python: A Computational ProblemSolving Focus, Wiley India Edition, 2013. 8.Paul Gries, Jennifer Campbell and Jason Montojo, —Practical Programming: An Introduction to Computer Science using Python 3‖, Second edition, Pragmatic Programmers, LLC, 2013.
5th	BT-***	Mass Transfer -I	Unit 1 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 2

			Absorption and Stripping: Equipments, Gas-liquid equilibrium, Henry's law, Selection of solvent, Absorption in tray column, Graphical and analytical methods, Absorption in packed columns, simultaneous heat and mass transfer studies in packed columns, HTU, NTU &HETP concepts, Design equations for packed column, Absorption with chemical reaction and mass transfer. Unit 3 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 4 Drying: Solid-gas equilibrium, 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 5 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.
5^{th}	BT-***	Chemical Reaction Engineering – II	Unit 1 Introduction to Homogeneous and Heterogeneous reactions, catalysts and Nature of catalysis, Physical properties of catalysts, determination of surface area, void volume and solid density, pore volume distribution; Classification, preparation, testing and

			characterization of solid catalysts, catalyst selection, catalyst promoters and inhibitors, catalyst poisoning and catalyst deactivation (no kinetics). Adsorption, physical adsorption and chemisorption, adsorption isotherms, mechanisms of catalytic reactions, Shifting of equilibrium in chemical reactions. Unit 2 Solid catalysed reactions, the rate equations for surface kinetics, Reaction and diffusion within porous catalysts, Pore diffusion resistance combined with surface kinetics, effectiveness factor and Thiele modulus, 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 porous catalyst particles, design of solid catalytic reactors. Unit 3 Fluid-solid reactions, experimental methods for finding rates, selection of a model, shrinking core model for spherical particles of unchanging size, rate of reaction for shrinking spherical particles, determination of rate controlling step, kinetics and design, Design of packed bed and fluidized bed reactors. Unit 4 Fluid-Fluid Reactions, Rate equation, rate equation for straight mass transfer, kinetic regimes of mass transfer and chemical reaction, rate equation for mass transfer and chemical reactions, fluid-fluid reactor design, deciding the contactor type and contacting pattern. Unit 5 Introduction to Biochemical reactions: Kinetics of Enzyme Fermentation and Microbial Fermentation, understanding of Biochemical Reactors and study of polymerization reactors, Bioprocessing of edible oils.
5^{th}	BT-***	Process Dynamics and	Unit 1 Dynamic modeling of first and second-order process; Interacting

		Control	and noninteracting processes; Nonlinear and integrating processes; introduction to nonminimum phase processes; Distributed parameter processes and MIMO processes; Response of first and second order processes with respect to different types of forcing functions. Unit 2 Experimental estimation of dynamic process parameters and identification. Modes of control action: Classification of controllers 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 using SCADA and DCS.
5^{th}	BT-***	Optimization Techniques	Unit 1 Optimization Optimization, Degree of freedom, Optimization formulation of the Problem, Analytical Method, Necessary and sufficient conditions for optimum in single and multi-variable unconstrained and constrained problems. Unit 2 Constrained and unconstrained variables Unconstrained one dimensional search, Newton, Quasi-Newton and Secant method for uni-dimensional search, Region climnation methods (Golden

			Section Fibonacci, Dichotomous etc), Unconstrained multivariable optimization with special focus to Powell's conjugate direction method. Unit 3 Optimization Techniques Linear Programming, graphical simplex method, revised simplex method, duality and transportation problems, unconstrained multi variable search, Direct methods, Indirect method. Unit 4 Finite Difference method Forward, Backward and Divided Differences Table, Central Differences, Newton's Forward, Backward and Divided Differences Interpolation Formula, Interpolation Polynomials, Lagrange Interpolation Formula, Sensitivity analysis. Unit 5 Optimality Principle of optimality, discrete and continuous dynamic programming. Algorithms & Computer Programming: Newton-Raphson Method, Gauss Elimination, Trapezoidal Rule, Simpson's 1/3rd, 3/8th Rule, Runge-Kutta 2nd Order, and R-K 4th Order Methods in reference to the Applications in Chemical Engineering.
5th	BT-***	Intellectual Property Rights & Standardization	Unit 1 Overview of Intellectual Property: Introduction to intellectual property right(IPR), intellectual property and its protection, Forms of Protection depending on product; Patent, copyright, trademark, design knowhow, trade secrets etc. Unit 2 Patents: Concept of quality mark and standardization, development in quality mark, bureau of Indian standards (BIS)and its role, IS, Ag Mark, BIS Hallmark, ECO mark, FPO mark , geographical indication mark under WTO /TRIPS, Bharat stage emissions,Toxicity labels; and vegetarian and non-vegetarian mark

			Unit 3 Copyrights: Quality council of India and its role, National accreditation body NABCB (National accreditation board for certification bodies),benefits of accreditation, Important legislations; National and International Unit 4 Trademarks: Patenting systems in India, requirements of filing a patent application, patents in R&D, opposition to grant of patent under Indian Patent act 1970, protection of chemical pharmaceutical and biotechnological inventions Unit 5 Other forms of IP Design: Management of intellectual property right (IPR's), quality management systems(QMS), ISO-9000 for manufacturing, ISO-14000 for environment, ISO -5000 for energy management systems, ISO - 22000 for Food safety management systems(FSMS), Information security management system(ISMS), Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition IP Laws
5th	BT-***	Constitution of India	Module 1--Introduction and Basic Information about Indian Constitution: Meaning of the constitution law and constitutionalism, Historical Background of the Constituent Assembly, Government of India Act of 1935 and Indian Independence Act of 1947,Enforcement of the Constitution, Indian Constitution and its Salient Features, The Preamble of the Constitution, Fundamental Rights, Fundamental Duties, Directive Principles of State Policy, Parliamentary System, Federal System, Centre-State Relations, Amendment of the Constitutional Powers and Procedure, The historical perspectives of the constitutional amendments in India, Emergency Provisions: National Emergency, President Rule, Financial Emergency, and Local Self Government – Constitutional Scheme in India.

			Module 2-Union Executive and State Executive: Powers of Indian Parliament Functions of Rajya Sabha, Functions of Lok Sabha, Powers and Functions of the President, Comparison of powers of Indian President with the United States, Powers and Functions of the Prime Minister, Judiciary – The Independence of the Supreme Court, Appointment of Judges, Judicial Review, Public Interest Litigation, Judicial Activism, LokPal, Lok Ayukta, The Lokpal and Lok ayuktas Act 2013, State Executives – Powers and Functions of the Governor, Powers and Functions of the Chief Minister, Functions of State Cabinet, Functions of State Legislature, Functions of High Court and Subordinate Courts. Module 3- Introduction and Basic Information about Legal System: The Legal System: Sources of Law and the Court Structure: Enacted law -Acts of Parliament are of primary legislation, Common Law or Case law, Principles taken from decisions of judges constitute binding legal rules. The Court System in India and Foreign Courtiers (District Court, District Consumer Forum, Tribunals, High Courts, Supreme Court). Arbitration: As an alternative to resolving disputes in the normal courts, parties who are in dispute can agree that this will instead be referred to arbitration. Contract law, Tort, Law at workplace. Module 4- Intellectual Property Laws and Regulation to Information: Intellectual Property Laws: Introduction, Legal Aspects of Patents, Filing of Patent Applications, Rights from Patents, Infringement of Patents, Copyright and its Ownership, Infringement of Copyright, Civil Remedies for Infringement, Regulation to InformationIntroduction, Right to Information Act, 2005, Information Technology Act, 2000, Electronic Governance, Secure Electronic Records and Digital Signatures, Digital Signature Certificates, Cyber Regulations Appellate Tribunal, Offences, Limitations of the Information Technology Act. Module 5 -Business Organizations and E-Governance: Sole

			Traders, Partnerships: Companies: The Company's Act: Introduction, Formation of a Company, Memorandum of Association, Articles of Association, Prospectus, Shares, Directors, General Meetings and Proceedings, Auditor, Winding up. E-Governance and role of engineers in E-Governance, Need for reformed engineering serving at the Union and State level, Role of I.T. professionals in Judiciary, Problem of Alienation and Secessionism in few states creating hurdles in Industrial development.
6th	BT-***	Mass Transfer -II	Unit 1 Distillation Pressure-composition, Temperature-concentration, Enthalpy-concentration diagrams for ideal and non-ideal solutions, Raoults law and its application, 8 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, min. 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 to multi component distillation system. Unit 3 Liquid-Liquid Extraction: Ternary liquid equilibrium, 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 equilibrium and adsorption hysteresis, Freundlich and Langmuir adsorption isotherm , Chemisorption Stage wise and continuous contact adsorption operations, Determination of number of stages, Equipments; Ion exchange, Equilibrium relationship, Principle of ion-exchange, techniques and applications, Principles and application of dialysis, osmosis reverse osmosis, thermal diffusion, sweep diffusion.
6^{th}	BT-***	Transport Phenomenon	Unit 1 Momentum Transport Viscosity - Temperature effect on viscosity of gases and liquids - Newton's law - Mechanism of momentum transport - Shell balance method - Pressure and velocity distributions in falling film - Circular tube - Annulus. Unit 2 Equations of Change and Turbulent Flow: Equation of continuity- Motion - Use of equations of change to solve flow problems - Dimensional analysis of equations of change - Comparison of laminar and turbulent flows - Timesmoothed equation of change. Unit 3 Energy Transport: Thermal conductivity - Temperature and pressure effect on thermal conductivity of gases and liquids - Fourier's law - Mechanism of energy transport - Shell energy balance - Temperature distribution in solids and laminar flow - with electrical - Nuclear - Viscous, Chemical heat source - Heat conduction through composite walls, cylinders – Spheres Unit 4 Temperature Distribution in Turbulent Flows: Energy equations

			- Use of equations of change - Dimensional analysis of equations of change - Timesmoothed equations of change - Empirical expressions - Temperature distribution for turbulent flow in tubes Unit 5 Mass Transport: Diffusivity - Temperature and pressure effect - Fick's law - Mechanism of mass transport - Theory of diffusion in gases and liquids - Shell mass balances - Concentration distribution in solids and in laminar flow: stagnant gas film - Heterogeneous and homogeneous chemical reaction systems- Falling film - Porous catalyst. The equation of continuity - Summary of equations of change and fluxes. Momentum, heat and mass transfer analogies: Chilton–Colburn analogy and Reynold's Analogy.
6th	BT-***	Chemical Technology	Unit 1 Introduction: Importance and Overview of Chemical Process Industries Starch, glucose and starch Fermentation products : Alcohol, Acetic acid, Citric acid and antibiotics 10 Cellulose - Derivatives of Cellulose- Carboxyl Methyl Cellulose and gun cotton, Structural aspects of cellulose. Oil, fats and waxes industry: properties of oils and fats, Saturated, mono-, di-, and polyunsaturated fatty acids, hydrogenation of edible oils, hydrogenolysis, esterification and randomization, refining, waxes, Fat Splitting, Soap, Surfactants, Emulsifiers, Glycerin,. Unit 2 Chlor-alkali industry: Common salt, Caustic soda and Chlorine, Soda Ash, Hydrochloric acid. Sulfur Industry: Sulfur and sulfuric acid, Oleum Phosphorus Industry: Phosphorus, Phosphoric acid and super phosphates, Nitrogen and Fertilizer Industry: Ammonia, Nitric acid, Urea and other nitrogen fertilizers, Mixed fertilizers (SSP, TSP, NPK, KAP, DAP, Nitro phosphate), Effect of changing feed raw material on fertilizer products, Bio-fertilizers, Agrochemical industries:

			Manufacturing process of some important pesticides, insecticides, fungicides, fumigants, herbicides and their uses. Unit 3 Paper industry: pulping; Recovery of chemicals from cooking liquors; Paper making. Wood Chemicals industry: Composite wood, plywood etc.; Manufacture of oleoresin, turpentine, menthol, Ethanol production; Essential oils, perfumes, flavors and cosmetics, Pharmaceutical industries: Classification and production of drugs Leather industry: Tanning processes; Leather making; Embossing; Leather chemicals. Unit 4 Surface coating industries: Types of surface coating; Paints, varnishes, distempers and enamels. Dyes industry: Classification of dyes and dye intermediates; production of some important dyes, lacquers and toners. Synthetic and natural fibers: Nylon, Dacron, Terylyne, Polyester, Viscose rayon, acetate rayon , Natural and synthetic rubber, vulcanization and reclaiming of rubber, SBR, Nano fibers Plastics; Thermosetting and Thermo Plastics (PVC, Polyethylene, Polyurethane, Teflon). Unit 5 Crude oil distillation, Thermal conversion processes (vis-breaking, coking), Catalytic conversion processes (fluid catalytic cracking, catalytic reforming, hydro cracking, alkylation, isomerization, polymerization),Finishing processes, Sulphur removal process, lube oil manufacture; Petrochemicals: ethylene, propylene, formaldehyde, methanol, ethylene oxide, ethanolamine, cumin, ethylene glycol, ethyl benzene, BTX; Separation of xylenes.
6^{th}	BT-***	Sustainability of Environment	Unit 1 Introduction: Interaction of man and environment, Ecology & Environment, components of the biosphere, biodiversity, Food chain, Environmental pollution from chemical process industries, characterization of emission and effluents,

			environmental Laws and rules (CPCB ,UPPCB), standards for ambient air, noise emission and effluents, concept of sustainable development. Unit 2 Resource Conservation: Process modification, alternative raw material, recovery of by co-product from industrial emission effluents, recycle and reuse of waste, energy recovery and waste utilization, Water use minimization. Unit 3 Air quality Control: Particulate emission control by mechanical separation and electrostatic precipitation, wet gas scrubbing, gaseous emission control by adsorption and adsorption, Design of cyclones, ESP, fabric filters and absorbers. Water Pollution Control: Physical treatment, pre-treatment, solids removal by settling and sedimentation, filtration centrifugation, coagulation and flocculation. Anaerobic and aerobic treatment biochemical kinetics, trickling filter, activated sludge and lagoons, aeration systems, sludge separation and drying and design of CETP, use of low waste technology. Unit 4 Solid Waste management: Industrial and Municipal, Characterization of wastes-hazardous and non-hazardous wastes. Waste disposal and management laws and guidelines. Non-hazardous industrial wastes-treatment, disposal, utilization and management. Value-extraction from the wastes. Handling, storage and disposal of hazardous wastes. Unit 5 Environment and Sustainable development: Economic development and social welfare consideration in socio economic developmental policies and planning. Impact of energy sources on environment, Approaches to mitigate environmental emissions from energy sector. Cleaner development mechanisms and their applications, Case studies on techno-economics of 7 V

			energy conservation and renewable energy technologies for making non renewable energy sources available over longer periods.
6th	BT-***	Understanding the human being comprehensively	Unit 1 Introduction: The basic human aspirations and their fulfillment 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 experience 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, selfawareness 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.
6th	BT-***	Essence of Indian Traditional Knowledge	Module 1- Society State and Polity in India State in Ancient India: Evolutionary Theory, Force Theory, Mystical Theory Contract Theory, Stages of State Formation in Ancient India, Kingship , Council of Ministers Administration Political Ideals in Ancient India Conditions' of the Welfare of Societies, The Seven Limbs of the State, Society in Ancient India, Purusārtha, Varnāshrama System, Āshrama or the Stages of Life, Marriage, Understanding Gender as a social category, The representation of Women in Historical traditions, Challenges faced by Women. Four-class Classification, Slavery. Module 2- Indian Literature, Culture, Tradition, and Practices Evolution of script and languages in India: Harappan Script and Brahmi Script. The Vedas, the Upanishads, the Ramayana and the Mahabharata, Puranas, Buddhist And Jain Literature in Pali,Prakrit And Sanskrit, Kautilya's Arthashastra, Famous Sanskrit Authors, Telugu Literature, Kannada Literature,Malayalam Literature ,Sangama Literature Northern Indian Languages & Literature, Persian And Urdu ,Hindi Literature Module 3- Indian Religion, Philosophy, and Practices Pre-Vedic and Vedic Religion, Buddhism, Jainism, Six System Indian Philosophy, Shankaracharya, Various Philosophical Doctrines , Other Heterodox Sects, Bhakti Movement, Sufi movement, Socio religious reform movement of 19th century, Modern religious practices. Module 4-Science, Management and Indian Knowledge System Astronomy in India, Chemistry in India, Mathematics in India, Physics in India, Agriculture in India, Medicine in India

			,Metallurgy in India, Geography, Biology, Harappan Technologies, Water Management in India, Textile Technology in India ,Writing Technology in India Pyrotechnics in India Trade in Ancient India/,India's Dominance up to Pre-colonial Times Module 5- Cultural Heritage and Performing Arts Indian Architect, Engineering and Architecture in Ancient India, Sculptures, Seals, coins, Pottery, Puppetry, Dance, Music, Theatre, drama, Painting, Martial Arts Traditions, Fairs and Festivals, Current developments in Arts and Cultural, Indian's Cultural Contribution to the World. Indian Cinema
7th	BT-***	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	BT-***	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	BT-***	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	BT-***	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	BT-***	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	BT-***	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	BT-***	Fertilizer	Unit 1

		Technology	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	BT-***	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.