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 : 2019-2020

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

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/Math IV	3	1	0	30	20	50		100		150	4
2	BT-***	Universal Human values/Technical comm.	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 Fluid Mechanics	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 Fluid Mechanics 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 Projector Internship Assessment*	0	0	2			50				50	1
10	BT-***	Computer Security system/python programming	2	0	0	15	10	25		50			0
11		MOOCs(Essential for Hons.Degree)											
		Total										**950**	**22**

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

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-***	Moths IV/Engineering science course	3	1	0	30	20	50		100		150	4
2	BT BT	Universal human value/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	ChemicalReaction 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	ChemicalReactionEngineeringLab	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/computer system security	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-***	Managerial Economics	3	0	0	20	10	30		70		100	3
2	BT-***	Sociology/cyber security	3	0	0	20	10	30		70		100	3
3	BT-***	Chemical Reaction Engineering	3	0	0	20	10	30		70		100	3
4	BT-***	Mass transfer-II	3	1	0	20	10	30		70		100	4
5	BT-***	Chemical Technology	3	0	0	20	10	30		70		100	3
6	BT-***	Deptt elective course-I	3	1	0	20	10	30		70		100	4
7	BT-***	Chemical reaction Engg Lab	0	0	2		50			50		100	1
8	BT-***	Mass tranfer Lab-II	0	0	2		50			50		100	1
9		Chemical Technology Lab	0	0	2		50			50		100	1
10	NC	Soft Computing Lab	0	0	2		50			50		100	1
11													
		Total	**18**	**2**	**8**	120	260				620	**1000**	**24**

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

Deptt. Elective: RCH051: Computational Fluid Dynamics RCH052: Optimization Techniques RCH053: Numerical Methods for Chemical Engineer RCH054: Statistical Design of Experiments

B.TECH III YEAR VI SEMESTER
CHEMICAL ENGINEERING

SEMESTER-VI													
Sl. No	**Subject Codes**	**Subject**	**Periods**			**EvaluationScheme**				**EndSemester**		**Total**	**Credit**
			L	**T**	**P**	**CT**	**TA**	**Total**	**PS**	**TE**	**PE**		
1	BT-***	Industrial Management	3	0	0	20	10	30		70		100	3
2	BT-***	Cyber Security	3	0	0	20	10	30		70		100	3
3	BT-***	Transport phenomena	3	0	0	20	10	30		70		100	3
4	BT-***	Process dynamic & Control	3	1	0	20	10	30		70		100	4
5		Chemical Reaction Engg-II	3	0	0	20	10	30		70		100	3
6	BT-***	Department elective course-2	3	1	0	20	10	30		70		100	4
7	BT-***	Flow sheeting Lab	0	0	2		50			50		100	1
8	BT-***	PDC Lab-I	0	0	2		50			50		100	1
9	NC	PDC Lab-II	0	0	2		50			50		100	1
10		CRE Lab-II	0	0	2		50			50		100	1
		Total	**18**	**2**	**8**	120	260			620		**1000**	**24**

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- 2019-20**

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 Technology**	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	**Mechanical Operation**	After successful completion of course the students should 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	**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	**Mathematics-IV**	The students will learn: CO1.The idea of partial differentiation and types of partial differential equations CO2. The idea of classification of second partial differential equations, wave , heat CO3.Equation and transmission lines The basic ideas of statistics including measures of central tendency, CO4. Correlation, regression and their properties. The idea s of probability and random variables and various discrete CO5. And continuous probability distributions and their properties. The statistical methods of studying data samples, hypothesis testing and statistical CO6. Quality control, control charts and their properties
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 -1I**	On successful completion of the course, the student will be able to: 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 CO3.Analyze the distillation process for binary and multi component mixtures CO4.Determine the number of stages required for separation of liquid-liquid and solid-liquid extractionprocess. CO5.Solvent selection for absorption and extraction operations CO6.Calculate drying rates and moisture content for batch and continuous drying CO7.Understand the adsorption mechanism and adsorption equilibrium
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	**Industrial Sociology**	After successful completion of the course the students will be able to: CO1. The course aims to introduce industrial and society. CO2. Describe the nature and scope of industrial sociology, growth of industrialization, industrial revolution and its impact on society. CO3. Understand labour meaning, problems. Understand impact of globalization on industry and labour.
5th	**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	**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 Reaction Engg-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	**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	**Cyber Security**	Students completing the course will be able to CO1. Students will be able to apply and manage secure coding practices throughout software project development. CO2. Capabilities and limitations. Students will be able to recognize insecure programming patterns and know how to replace them with secure alternatives CO3.Students will gain a good comprehension of the landscape of software security vulnerabilities, with specifics for various programming languages and types of software applications CO4. Students will gain the ability to analyze the security of a software system and convincingly advocate about the significance of vulnerabilities CO5.Students will know representative tools for software security analysis and testing, use them in practice and understand their
6th	**Industrial Management**	On successful completion of the course, the student will be able to: CO1. Understand the concepts related to Business. CO2. Demonstrate the roles, skills and functions of management.

		CO3. Analyze effective application of PPM knowledge to diagnose and solve organizational problems and develop optimal managerial decisions. CO4. Understand the complexities associated with management of human resources in the organizations and integrate the learning in handling these complexities.
7th	**Process Equipment Design**	After completion of this course, student will be able to: CO1. Able to process design of shell & tube heat exchanger. CO2. Able to process design of plate heat exchanger. CO3. Able to process design of sieve tray distillation column. CO4. Able to process design of packed bed distillation column
7th	**Process Modelling Simulation**	After completion of this course, student will be able to: CO1. Analyze physical and chemical phenomena involved in various processes. CO2. Develop mathematical models for various chemical processes. CO3. Use various simulation approaches. CO4. Simulate a process using process simulators (ASPEN Plus/ ASPEN Hysys).
7th	**Industrial Pollution Abatement Methods**	After completion of this course, student will be able to: CO1. Quantify and analyze the pollution load.

7th	**Nano Technology**	CO2. Analyze/design of suitable treatment for wastewater CO3. Model the atmospheric dispersion of air pollutants. CO4. Selection and design of air pollution control devices CO4. Analyze the characteristics of solid waste and its handling & management After completion of this course, student will be able to: CO1.Apply principles of basic science concepts in understanding, analysis and prediction of matter at Nano scale. CO2.To introduce interdisciplinary subjects/concepts/ideas for interdisciplinary application of Science and engineering concepts CO3.To introduce advanced ideas and techniques required in emergent area of nanotechnology. CO4.To develop human resource with specialization in theoretical and experimental techniques required for career in academia and Nano technology driven industry CO5.Engage in lifelong learning and adapt to changing professional and societal need
7th	**Energy Management**	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 CO3.To acquire the knowledge of modern energy conversion technologies CO4.To be able to understand and perform the various characterization techniques of fuels

		CO5.To be able to identify available nonconventional (renewable) energy resources and techniques to utilize them effectively.
8th	**Fertiliser 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	**Process Utility and Safety in Chemical Plant**	At the end of this course students will be able to: CO1. Understanding of Safety principles. CO2. Ability to do Hazard analysis. CO3. Ability to do event tree and fault tree analysis
8th	**Petroleum Refining**	At the end of this course students will be able to …

		CO1. Introduction with the petroleum refinery worldwide CO2. Develop knowledge of different refining processes CO3. Develop knowledge of safety and pollution control in the refining industries. CO4. To find the suitable refining technology for maximizing the gasoline yield

Syllabus

Semester	Course Name and Course Code	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 Technology**	**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	**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**
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	**Mathematics-IV**	Unit-1- Partial Differential Equations Origin of Partial Differential Equations, Linear and Non Linear Partial Equations of first order, Lagrange's Equations, Charpit's method, Cauchy's method of Characteristics, Solution of Linear Partial Differential Equation of Higher order with constant coefficients, Equations reducible to linear partial differential equations with constant coefficients. Unit-2- Applications of Partial Differential Equations: Classification of linear partial differential equation of second order, Method of separation of variables, Solution of wave and heat conduction equation up to two dimension, Laplace equation in two dimensions, Equations of Transmission lines. **Unit-3**- Statistical Techniques I:

		Introduction: Measures of central tendency, Moments, Moment generating function (MGF) , Skewness, Kurtosis, Curve Fitting , Method of least squares, Fitting of straight lines, Fitting of second degree parabola, Exponential curves ,Correlation and Rank correlation, Regression Analysis: Regression lines of y on x and x on y, regression coefficients, properties of regressions coefficients and non linear regression. **Unit-4**- Statistical Techniques II: Probability and Distribution: Introduction, Addition and multiplication law of probability, Conditional probability, Baye's theorem, Random variables (Discrete and Continuous Random variable) Probability mass function and Probability density function, Expectation and variance, Discrete and Continuous Probability distribution: Binomial, Poission and Normal distributions. **Unit-5**- Statistical Techniques III: Sampling, Testing of Hypothesis and Statistical Quality Control: Introduction , Sampling Theory (Small and Large) , Hypothesis, Null hypothesis, Alternative hypothesis, Testing a Hypothesis, Level of significance, Confidence limits, Test of significance of difference of means, T-test, F-test and Chi-square test, One way Analysis of Variance (ANOVA).Statistical Quality Control (SQC) , Control Charts , Control Charts for variables (X and R Charts), Control Charts for Variables (p, np and C charts). **Text Books** 1. Erwin Kreyszig, Advanced Engineering Mathematics, 9thEdition, John Wiley & Sons, 2006. 2. P. G. Hoel, S. C. Port and C. J. Stone, Introduction to Probability Theory, Universal Book Stall, 2003(Reprint). 3. S. Ross: A First Course in Probability, 6th Ed., Pearson Education India, 2002. 4. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Ed., Wiley, 1968.

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	**Mass Transfer -1I**	**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	**Optimization Technique**	**Unit-1** Analysis method necessary and sufficient conditions for optimum in single and multivariable unconstrained and constrained problems

		Unit-2 Unconstrained one dimensional search Newton, Quasi Newton and secant Method for Unidimensional search, Region elimination methods (golden section, Fibonacci, Dichotomous etc.) **Unit-3** Linear Programming**,** Graphical simplex method, revised simplex method, duality and transportation problems. Unconstrained multivariable search, Direct methods, Indirect methods. **Unit-4** Finite difference approximation, Dynamic Programming **Unit-5** Principle of optimality, Discrete and continous dynamic Programming. Books: 1 T.F. Edgar and D.M. Himmelblau Optimization of Chemical Process-McGraHill (1989) 2. K Urbanier and C.Mc Dermott-Optimal Design Process Equipment-John Wiley(1986)
5th	**Chemical Technology**	**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 andRevised 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	**Industrial sociology**	**Unit-1** **Industrial Sociology**: Nature, Scope and Importance of Industrial Sociology. Social Relations in Industry, Social Organisation in Industry- Bureaucracy, Scientific Management and Human Relations. **Unit-2** Rise and Development of Industry: Early Industrialism – Types of Productive Systems – The Manorial or Feudal system. The Guild system, The domestic or putting-out system, and the Factory system. Characteristics of the factory system. Causes and Consequences of industrialization. Obstacles to and Limitations of Industrialization **Unit-3** Industrialization in India. Industrial Policy Resolutions – 1956.Science. Technology and Innovation Policy of India 2013 **Unit-4** Contemporary Issues: Grievances and Grievance handling Procedure. Industrial Disputes: causes, Strikes and Lockouts. Preventive Machinery of Industrial Disputes: Schemes of Workers Participation in Management- Works Committee, Collective Bargaining, Bi-partite & Tri-partite Agreement, Code of Discipline, Standing Orders. Labour courts & Industrial Tribunals. **Unit-5** Visualizing the future: Models of industrialization- Collectivist, anarchist, free market, environmentalist, etc. Cultural issues, consumer society and sociological concerns. **References:**

		1. PREMVIR KAPOOOR, Sociology & Economics for Engineers, Khanna Publishing House (Edition 2018). **2. GISBERT PASCAL, Fundamentals of Industrial sociology, Tata McGraw Hill, New Delhi, 1972.** **2. SCHNEIDER ENGNO V., Industrial Sociology 2nd Ed., McGraw Hill Publishing Co., New Delhi, 1979.** **3. MAMORIA C.B. And MAMORIA S., Dynamics of Industrial Relations in India.** **4. SINHA G.P. and P.R.N. SINHA, Industrial Relations and Labour Legislations, New Delhi, Oxford and IBH Publishing Co., 1977.**
6th	**Process dynamic control**	**UNIT 1** 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 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 **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	**Chemical Reaction Engg-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	**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**,
6th	**Cyber security**	**Unit-1** **Introduction**- Introduction to Information Systems, Types of Information Systems, Development of Information Systems, Introduction to Information Security, Need for Information Security, Threats to Information Systems, Information Assurance, Cyber Security, and Security Risk Analysis **Unit-2** **Application Security**- (Database, E-mail and Internet), Data Security Considerations-Backups, Archival Storage and Disposal of Data, Security Technology-Firewall and VPNs, Intrusion Detection, Access Control. Security

		Threats -Viruses, Worms, Trojan Horse, Bombs, Trapdoors, Spoofs, E-mail Viruses, Macro Viruses, Malicious Software, Network and Denial of Services Attack, Security Threats to E-Commerce- Electronic Payment System, e- Cash, Credit/Debit Cards. Digital Signature, Public Key Cryptography **Unit-3** Developing Secure Information Systems- Application Development Security, Information Security Governance & Risk Management, Security Architecture & Design Security Issues in Hardware, Data Storage & Downloadable Devices, Physical Security of IT Assets, Access Control, CCTV and Intrusion Detection Systems, Backup Security Measures. **Unit-4** Security Policies- Development of Policies, WWW Policies, Email Security Policies, Policy Review Process-Corporate Policies-Sample Security Policies, Publishing and Notification Requirement of the Policies. Evolving Technology Security – Mobile, Cloud, Outsourcing, SCM **Unit-5** Information Security Standards-ISO, IT Act, Copyright Act, Patent Law, IPR. Cyber Laws in India; IT Act 2000 Provisions, Intellectual Property Law: Copy Right Law, Software License, Semiconductor Law and Patent Law. Case Study – Corporate Security **References:** **1. Charles P. Pfleeger, Shari Lawerance Pfleeger, "Analysing Computer Security", Pearson Education India.** **2. V.K.Pachghare, "Cryptography and information Security", PHI Learning Private Limited, Delhi India.** **3. Sarika Gupta & Gaurav Gupta, Information Security and Cyber Laws, Khanna Publishing House** **4. Anshul Kaushik, Cyber Security, Khanna Publishing House** **5. Dr.Surya Prakash Tripathi, Ritendra Goyal, Praveen Kumar Shukla ,"Introduction to Information Security and Cyber Law" Willey Dreamtech Press.**

6th	**Industrial Management**	**Unit-1** Introduction: Concept and scope of Industrial Management. Productivity: Definition, measurement, productivity index, types of production system, Industrial Ownership. **Unit-2** Functions of Management, Taylor's Scientific Management Theory, Fayol's Principles of Management, Social responsibilities of Management, Introduction to Human resources management: Nature of HRM, functions and importance of HRM **Unit-3** **Work Study**: Introduction, definition, objectives, steps in work study, Method study: definition, objectives, steps of method study, Work Measurement: purpose, types of study — stop watch methods — steps — allowances — standard time calculations — work sampling, Production Planning and Control Inventory Control: Inventory, Cost, Models of inventory control: EOQ, ABC, VED **Unit-4** Quality Control: statistical quality control, Control charts for variables and attributes, Acceptance Sampling- Single sampling- Double sampling plans, Introduction to TQM. **Unit-5** Project Management: Project network analysis, CPM, PERT and Project crashing and resource Leveling **References:** **1. Engineering Management (Industrial Engineering & Management)/ S.C. Sharma & T.R. Banga, Khanna Book Publishing Co. (P) Ltd., Delhi (ISBN: 978-93-86173-072)** **2. Industrial Engineering and Management/ P. Khanna, Dhanpatrai publications Ltd.** **3. Production & Operation Management /PaneerSelvam /PHI.** **4. Industrial Engineering Management/NVS Raju/Cengage Learning**
7th	**Process Equipment Design**	**Unit I** Introduction to various mechanical properties of materials to be used as material of construction, resistance of metals to corrosion under varying conditions of

		temperature and pressure etc. Application and use of various codes and standards in design. **Unit II** Design of non-pressure storage vessel, tall vertical vessels, unfired pressure vessels with internal pressure ,Design of unfired pressure vessels with external pressures, end closures, flat plates, domed ends, torispherical, ellipsoidal, hemispherical and conical ends. Design of nozzles, openings and reinforcements, Bolts, flanges, gaskets **Unit III** Bolted flanges, pipe line design and process design of a few equipments like heat exchangers, Evaporators, Distillation columns, Absorbers, Reactors and Dryers . **Unit IV** Mechanical design of selected process equipments such as heat exchangers, Evaporators, 29 Distillation columns, Absorbers, Reactors and Dryers and Crystallizers; Use of softwares for design of equipments. **Text Books** **1. Peters Max. S., Timmerhaus Klaus D.and Ronald E West "Plant Design and Economics for Chemical Engineers".2003 V Edition McGraw Hill.** **2. Coulson, J. M. and Richardson J. F. "Chemical Engineering", vol. 6 Pargamon Press. (1989).** **3. Brownel and Young, "Process Equipment Design ".Wiley (1968).** **Reference Books** **1. Indian and American Codes Used in Designing of equipments (TEMA and IS Codes)** **2. Evans, F. L., "Equipment Design Handbook", Gulf Publishing Company.(1979**)
8th	**Fertilizer Technology**	Unit 1 Introduction to fertilizers: Introduction to Plant nutrients, Fertilizer specifications, Terminology and Definitions, Classifications of Soil nutrients, Fundamentals of Soil Nitrogen, Soil Phosphorus, Soil Potassium and Soil Sulfur. Unit-2 Nitrogenous Fertilizers:Methods of production, characteristics, storage and handling specificationsof Ammonium Nitrate, Calcium Ammonium Nitrate, Ammonium Chloride, Ammonium Sulphate, Urea. Unit-3

Phosphatic Fertilizers:Raw materials: Phosphate rock, Sulphur pyrites, Sulphuric acid and Phosphoric acid, Methods of production, characteristics and specifications of Single Super Phosphate, Triple Super phosphate, Ammonium Phosphates: SAP, DAP.

Unit-4

Potassic Fertilizers: Methods of production, specification, characteristics of Potassium Sulphate,Potassium Chloride, Potassium Nitrate Compound Fertilizers, NPK Fertilizers, Complex Fertilizers.

Unit-5

Fertilizers and Environment: Environmental issues related to the use of fertilizers, impact of fertilizers on the environment, Solid, Liquid and Gaseous pollution from fertilizer industries, Bio fertilizers, Green fertilizers.

REFERENCE BOOKS:

S. NO.	NAME OF AUTHORS/BOOKS/PUBLISHERS	Year Of Publication/ Reprint
1.	M. Gopala Rao & Marshall Sittig, Dryden's Outlines of Chemical Technology, East-West Press, 3rd Edition, New Delhi.	2015
2.	Austin G. T, Shreve's Chemical Process Industries, 5th edition, Mc. Graw Hill Publications.	2017
3.	Pandey & Shukla, Chemical Technology, Volume I & II, 2nd Edition, Vani Books Company.	2018
4.	John J. Mortvedt, Roy H. Follett, Larry S. Murphy, Fertilizer Technology and Application, Meister Publishing Company.	1999
5.	Slack A.V., Chemistry & Technology of Fertilizers, Interscience, New York.	1967

8th	**Renewable Energy Resources**	Unit-1 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-2 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 energystorage for solar heating and cooling, limitations. Unit-3 Geothermal Energy: Resources of geothermal energy, thermodynamics of geo-thermal energy conversion-electrical conversion, non-electrical conversion, environmental considerations. Magneto-hydrodynamics (MHD): Principle of working of MHD Power plant, performance and limitations. Cells: Principle of working of various types of fuel cells and their working, performance and limitations. Unit-4 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-5 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

		Text Book: 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	**PROCESS UTILITY & SAFETY IN CHEMICAL PLANTS**	**Unit 1** Various process utilities, their role and importance in chemical plants. Water Sources of water and their characteristics: Treatment storage and distribution of water; water for use in boilers, cooling purposes, drinking and process; Reuse and conservation of water: Water resource management. **Unit2** Steam Generation and Utilization Steam Generation and its application in chemical process plants, distribution and utilization: Design of efficient steam heating systems: steam economy, steam condensers and condensate utilization Expansion joints, flash tank design, steam traps their characteristics, selection and application, waste heat utilisation; Lagging, selection and thickness. Selection and sizing of boilers; waste heat boilers. **Unit3** Compressors, blowers and Vacuum Pumps Compressors, blowers and vacuum pumps and their performance characterisstics; Methods of developing vacuum and their limitations, material handling under vacuum, Piping systems; Lubrication and oil removal in compressors and pumps. Air filters. Air gas leakage. Inert gas systems. Compressed air for process, Instrument air. Insulation Importance of insulation for meeting the process requirements, installation materials and their effect on various material of equipment piping, fitting and valves etc, insulation for high intermediate, low and sub zero temperatures, including cryogenic insulation. **Unit 4** Elements of safety Elements of safety, safety and site selection; Plant and unit plot planning; Definition of risk and hazard Identification and assessment of the hazard and risk, Industrial between hazards and risk, Industrial hgiene, toxicological studies, Hazard operability (HAZOP) hazard analysis (HAZAN); Assessment of the risk, fault tree, event tree, scope of risk assessment; control of hazards, controlling toxic chemicals and

		controlling flammable materials. Prevention of losses Prevention of losses, Pressure relief, fire & explosions, Provision of fire fighting equipments, Technology selection and transfer, choosing the right process. **Unit 5** Control of Process Control of process, Prevention of hazardous deviation in process variable, e.g. pressure, temperature flow by Provision of automatic control systems-interlocks, alarms, trips together with good operating practices and management. Accidental analysis, Regulations and legislation, Role of gevemment role, risk management routines and tackling disaster,case studies. **Text Books:** **1. Nordell Eskel, "Water Treatment for Industrial and Other Uses", Reinhold Publishing Corporation, New York. (1961)** **2. Crowl, D.A. & Louvar, J.F.. "Chemical Process Safety: Fundamentals with applications", New Jersey: Prentice-Hall. (1989)** **3. Goodall, P.M., "The Efficient use of Steam" IPC Science and Technology (1980)** **4. O P Gupta, "Chemical Process Technology"' Khanna Publishing House**
8th	**Petroleum Refining**	**Unit I** Petroleum Exploration Production and Refining of Crude oils Crude oils: Chemistry and composition (Characteristics and constituents of crude oils, Classification of crude oils). **Unit II** Quality Control of Petroleum Products Classification of laboratory tests, distillation, vapour pressure, flash and fire points, octane number, performance number, cetane number, aniline point, viscosity index, calorific value, smoke point, char value, viscosity, viscosity index, penetration tests, cloud and pour points, drop point of grease, melting and settling points of wax, softening point of Bitumen, induction period of gasoline, thermal stability of jet fuels, gum content, Total Sulphur, Acidity and Alkalinity,, Copper Strip Corrosion Test, Silver – Strip Corrosion Test for ATF, Ash, Carbon Residue (Conradson method, Ramsbottom method) Colour, Density and Specific gravity, Refractive index of hydrocarbon liquids, water separation index (modified) (WSIM), ductility.

		Unit III Petroleum Products Composition, Properties & Specification of LPG, Naphthas, motor spirit, Kerosine, Aviation Turbine Fuels, Diesel Fuels, Fuel Oils, Petroleum Hydrocarbon Solvents, Lubricating oils (automotive engine oils, industrial lubricating oils electrical insulating oils, Jute Batching oils, white oils, steam turbine oils, metal working oils, etc.) Petroleum Waxes Bitumens, Petroleum coke. Crude Oil Distillation Desalting of crude oils, Atmospheric distillation of crude oil, Vacuum distillation of atmospheric residue. Thermal Conversion Process Thermal Cracking Reactions, Thermal Cracking, Visbreaking, (Conventional Visbreaking and Soaker Visbreaking) Coking (Delayed Coking, Fluid Coking, Flexicoking), Calcination of Green Coke. **Unit IV** Catalytic Converson Process Fluid catalytic cracking; Catalytic reforming; Hydrocracking Catalytic Alkylation, Catalytic Isomerization; Catalytic Polymerization. Finishing Process Hydrogen sulphide removal processes; Sulphur conversion processes; Sweetening processes (Caustic treatment, Solutizer process; Doctor treating process; Copper chloride sweetening,; Hypochlorite sweetening ;Air and inhibitor treating process; Merox processes;Sulphuric acid treatment; Clay treatment); Solvent extraction processes (Edeleanu process, Udex process, Sulfolane process), Hydrotreating processes. **Unit V** Lube Oil Manufacturing Process Evaluation of crude oils for lube oil base stocks, Vacuum distillation, Solvent deasphalting Solvent extraction of lube oil fractions (Furfural, NMP and Phenol), Solvent dewaxing, Hydrofinshing, Manufacture of petroleum waxes (Wax sweating, Solvent deoiling) Manufacture of Bitumens Selection of crude oil, Methods of manufacture of bitumens, (Distillation, Solvent 43 precipitation, Air blowing)

		Books Recommended **1. Nelson, W.L., Petroleum Refining Engineering, McGraw Hill** **2. Mall, I D ,Petrochemical Process Technology, McMillan India** **3. Sarkar,G.N., Advance Petroleum Refining, Oscar Publication**
7th	**Energy Management**	. **Unit I** Energy Scenario Commercial & Non commercial energy, primary energy resources, commercial energy production, final energy consumption, energy need of growing economy, long term energy scenario, energy pricing, energy sector reform, energy & environment, energy conservation and its importance, re- structuring of the energy supply sector, energy strategy for future, energy conservation act. **Unit I**I Energy Management & Energy Planing Definition & significance, energy strategy, energy policy & energy planning, two sides of energy management, sectors of supply side energy management, objective of energy management, hierarchical levels of supply side energy management, trade off b/w energy management, energy strategies & energy planning, energy & economy, essential imperatives & steps in supply side energy planning, energy planning flow for supply side, essential data for supply side energy planing, infrastructure planning, transportation of energy, per capita energy consumption, imperatives & steps in user side energy planning, energy management & control system for demand side, seven principal of energy management, energy policy of a supply organization & demand side organization, organization for energy management, training & human resource development, motivation. **Unit III** Energy Audit & Energy Monitoring, Targeting and Conservation Introduction, need, types & procedure of energy audits, modern techniques and instruments for energy audit. Defining monitoring & targeting, element of monitoring &

		targeting, data & information analysis, techniques- energy consumption, production & cumulative sum of differences (CUSUM). Energy conservation opportunity, electrical & thermodynamic ECOs, ECOs in chemical process industries, waste management & recycling of discard material and energy. **Unit IV** Advancement In Technologies & Future Energy Alternatives 23 Recent advancement in energy technology towards 21st century, transport of energy, ethanol as a fuel. Fusion – introduction potential, condition for fusion, magnetic confinement fusion reactor, cold fusion laser induced fusion. Biomass –introduction, municipal waste, biomass conversion, wood combustion Geothermal energy – introduction, origin, nature, resources and exploration, environment impact, low temperature geothermal resources. **Unit V** Case Studies Energy conservation in alcohol industry. Energy conservation in fertilizer industry and pulps & paper industry. Energy conservation in different units of refinery likes FCCU, HCU & ADU. **Text Books** **1. Murphy W.R. and Mckay G., Energy Management(BH)** **2. Hinrich & Kleinbach "Energy : its use and the environment" III ed. Harcourt.** **3. Boyle "Renewable Energy : Power for a sustainable future" Oxford.** **4. Rao S. & Parulckar B.B. "Energy technology" khhanna publisher** **5. Capenart & Turner " Guide to energy management " 6 ed. Keinnedu fairmant press**