

<b>BA23152</b>	<b>TOTAL QUALITY MANAGEMENT</b>			<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	know the importance of quality management, customer perception and retention.						
2	acquaint with the principles and philosophies of quality management						
3	understand the significance of statistical process control for quality management.						
4	ascertain quality management tools and techniques						
5	gain knowledge of quality management system standards and their implementation across sectors						
<b>UNIT I</b>	<b>INTRODUCTION TO QUALITY MANAGEMENT</b>						<b>9</b>
TQM: definitions, framework, benefits – Quality: vision, mission and policy statements- Customer Focus : customer perception of quality, translating needs into requirements- Dimensions of product and service quality, cost of quality - Service and Product quality - Foundation of TQM							
<b>UNIT II</b>	<b>PRINCIPLES AND PHILOSOPHIES OF QUALITY MANAGEMENT</b>						<b>9</b>
Principles of Juran, Crosby, Ishikawa, Taguchi techniques: loss function, parameter and tolerance design - Quality circle - Japanese 5S principles - 8D methodology - SMART Goal Setting for Quality - Deming's principles - PDCA Cycle							
<b>UNIT III</b>	<b>STATISTICAL PROCESS CONTROL AND TQM TECHNIQUES</b>						<b>9</b>
Meaning and significance of statistical process control (SPC) – Control charts for variables and attributes - Process capability :meaning, significance and measurement – Business process re-engineering(BPR) - ERP: Role of ERP –Cause and Effect Diagram-Root Cause Analysis- New 7 QC Tools - Benchmarking							
<b>UNIT IV</b>	<b>TOOLS AND TECHNIQUES FOR QUALITY MANAGEMENT</b>						<b>9</b>
Process capability- Quality Function Development (QFD): concepts, improvement needs and performance measures - Poka Yoke and Fool proofing Techniques - Quality Management Systems (QMS) : frameworks, documentation-Quality Auditing: Purpose and process- AI in Total Productive Maintenance							
<b>UNIT V</b>	<b>QUALITY SYSTEMS AND IMPLEMENTATION</b>						<b>9</b>
ISO 9000: Need, Concepts, Documentation- Elements of ISO 9001:2015 – System Elements and Audit Process - QS 9000, ISO 14000: Requirements and Benefits - ISO Certification Process -TQM Implementation in Manufacturing and Service Sectors- Quality Assurance vs Quality Control - Quality Awards - Six sigma concepts - AI based Quality Inspection Systems							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	construct effective quality policies					Synthesis (K5)	
CO2	apply the quality philosophies and practices in business					Applying (K3)	

CO3	implement the statistical process control and process capability to enhance quality.	Applying (K3)
CO4	examine the quality tools to enhance organization's quality performance	Analyzing (K4)
CO5	understand the role of quality auditing and ISO standards in quality management	Understanding (K2)

**TEXT BOOKS**

1. Total Quality Management, by Dale H. Besterfield, 5th Edition, 2021, Pearson Education
2. Quality Management for Organizational Excellence: Introduction to Total Quality by David L. Goetsch & Stanley Davis, 9th Edition, 2021, Pearson.

**REFERENCE BOOKS**

3. Fundamentals of Quality Control and Improvement by Amitava Mitra, 5th Edition, , 2021, Wiley
4. Total Quality Management by P.N Mukherjee 2nd Edition, 2024, PHI Learning
5. Total Quality Management: Key Concepts and Case Studies by D.R. Kiran 2nd Edition, 2020, Butterworth-Heinemann
6. Fundamentals of quality control and improvement by Mitra, A ,5th Edition, 2021, Wiley

**CO-PO MAPPING :**

**Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes PSO's (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak**

CO's	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	1	-	1	-	-
CO2	-	1	-	1	1	1
CO3	-		1	-	1	1
CO4	1	1	1	-	-	-
CO5	-	1	1	-	1	1



<b>CM23501</b>	<b>CHEMICAL ENGINEERING THERMODYNAMICS</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	use the laws of thermodynamics for open and closed systems				
2	understand thermodynamic systems using first laws and PVT behavior of fluids				
3	analyze thermodynamic cycles and entropy.				
4	evaluate thermodynamic property relations.				
5	learn the concepts of power generation and refrigeration processes				
<b>UNIT I</b>	<b>BASICS AND FIRST LAW OF THERMODYNAMICS</b>				<b>9</b>
Definitions and fundamental concepts – systems and processes, Homogeneous and heterogeneous systems, Closed and Open systems, Intensive and extensive properties, State and path functions, Temperature and Zeroth law; Heat reservoirs and heat engines, Reversible and Irreversible Processes. First Law of Thermodynamics for cyclic, flow and non-flow process, Internal energy and enthalpy.					
<b>UNIT II</b>	<b>PVT BEHAVIOR AND HEAT EFFECTS</b>				<b>9</b>
PVT behaviour of fluids – Equation of state and the concept of ideal gas, Processes involving ideal gases, Equations of state for real gases, Generalized Compressibility chart factor correlation; generalized equations of state – van der Waals, Redlich-Kwong, Peng Robinson, effect of temperature on standard heat of reaction.					
<b>UNIT III</b>	<b>SECOND LAW OF THERMODYNAMICS</b>				<b>9</b>
Statements of the second law of thermodynamics, Entropy and the Nature of the Process, Carnot cycle and Carnot theorems, thermodynamic temperature scale, Calculation of entropy changes – phase change, process involving ideal gases, adiabatic and isothermal mixing processes, Entropy and irreversibility, Third law of thermodynamics.					
<b>UNIT IV</b>	<b>THERMODYNAMIC PROPERTIES</b>				<b>9</b>
Thermodynamic properties – reference, energy and derived, Helmholtz free energy, Gibbs free energy; thermodynamic property relations – Maxwell relations – Clapeyron equations, Entropy – Heat capacity relationships, Relationship between $C_p$ and $C_v$ , Joule-Thomson co-efficient, Effect of temperature and pressure on fugacity, Construction of thermodynamic diagrams.					
<b>UNIT V</b>	<b>APPLICATIONS OF THERMODYNAMICS</b>				<b>9</b>
Flow Processes – Continuity, energy equation, Flow in pipes, flow through nozzles, Refrigeration – Coefficient of performance, capacity, Carnot cycle and heat pumps. Liquefaction processes – vaporization of liquid, free expansion. Steam power plant – Rankine cycle, reheat cycle and regenerative cycle.					
<b>TOTAL PERIODS</b>					<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	apply the fundamental concepts of thermodynamics and its related functions	Applying (K3)												
CO2	apply second law and analyse the feasibility of system/devices	Applying (K3)												
CO3	analyse thermodynamic properties of system/devices	Analyzing (K4)												
CO4	analyse the thermodynamic property relations and their application to fluid flow	Evaluating (K5)												
CO5	apply thermodynamic concepts to practical systems	Applying (K3)												
<b>TEXT BOOKS</b>														
1. J.M. Smith, H.C. Van Ness and M.M. Abbott, "Introduction to Chemical Engineering Thermodynamics", 7th edition, McGraw-Hill International Edition, 2005.														
2. Narayanan, K. V. "Chemical Engineering Thermodynamics." Prentice Hall India Learning Private Limited; 2nd revised edition (2013).														
<b>REFERENCES</b>														
1. Sandler, S.I. "Chemical and Engineering Thermodynamics", IV Edition, Wiley, 2006.														
2. Rao, Y. V. C. "Chemical engineering thermodynamics", Universities Press, 1997.														
3. Kevin Douglas, "Fundamentals of Chemical Engineering Thermodynamics", Timothy Anderson 2015														
4. M J Moran, H N Shapiro, D D Boettner and M B Bailey, "Principles of Engineering Thermodynamics", 8th Edition, Wiley.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	-	1	-	2	-	-	2	1	-	3	3
CO2	3	2	-	2	1	-	-	-	1	1	-	1	2	2
CO3	3	3	3	2	-	2	2	1	3	2	1	1	3	2
CO4	2	2	2	2	2	1	1	2	3	1	2	2	2	2
CO5	2	2	1	-	-	1	1	2	1	1	2	-	2	3



CM23502	<b>CHEMICAL REACTION ENGINEERING I</b>	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	understand reaction rate theories, kinetic data and design of batch reactor					
2	develop skills in experimental kinetic data analysis for various reaction types.					
3	understand the working principles and design equations of ideal reactors and their combinations.					
4	learn the effect of thermal and pressure conditions on reaction behaviors and design.					
5	equip non-ideal flow patterns and model reactor behavior using RTD analysis.					
<b>UNIT I</b>	<b>CHEMICAL KINETICS</b>	<b>9</b>				
Rate equation, elementary, non-elementary reactions, theories of reaction rate and prediction; Design equation for constant and variable volume batch reactors, analysis of experimental kinetics data, Half-life calculation						
<b>UNIT II</b>	<b>DATA ANALYSIS AND INTERPRETATION</b>	<b>9</b>				
Methods for kinetic data collection, analysis of rate data, rate data in constant volume & variable volume systems, irreversible unimolecular first order, second and third order reactions, reversible reactions, kinetics of irreversible relations in series and parallel						
<b>UNIT III</b>	<b>DESIGN OF IDEAL REACTOR AND MULTIPLE REACTOR SYSTEM</b>	<b>9</b>				
Ideal reactor, classification of reactors based on mode of operation, working principle & performance equation for batch reactor, PFR, CSTR, Recycle reactor, Autocatalytic reactions. Concept of space time and space velocity, Size comparison of single reactors. Plug flow reactors in series and parallel, Mixed Flow Reactors of equal and different sizes in series. Reactors of different types in series.						
<b>UNIT IV</b>	<b>TEMPERATURE AND PRESSURE EFFECTS</b>	<b>9</b>				
Single reactions - Heats of Reaction from Thermodynamics, Equilibrium Constants from Thermodynamics, General Graphical Design Procedure, Optimum Temperature Progression, Adiabatic and non-adiabatic operations, Multiple reactions - Product Distribution and Temperature.						
<b>UNIT V</b>	<b>NON-IDEAL FLOW</b>	<b>9</b>				
Residence time distribution Function. Relationship among E, F and C curves. Moments of RTD. Models for non-ideal flow - Segregation, Tanks in series and Dispersion models. Reactor modelling with RTD						
					<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>						
At the end of this course, students will be able to					<b>BT Mapped (Highest Level)</b>	
CO1	derive rate equations for different chemical reactions and reactor types.				Apply (L3)	
CO2	interpret kinetic data for complex reaction systems.				Analyse (L4)	
CO3	evaluate the performance of batch, PFR, and CSTR reactors.				Analyse (L4)	
CO4	assess multiple reactor arrangements for efficient chemical processing.				Apply (L3)	
CO5	analyze non-ideal flow behavior in reactors using RTD and flow models.				Analyse (L4)	

TEXT BOOKS														
1. Octave Levenspiel, Chemical Reaction Engineering, Third Edition, an Indian adaption, Wiley, 2021.														
2. Lanny D. Schmidt, "The Engineering of Chemical Reactions", Second Edition, Oxford University Press, 2005														
REFERENCES														
1. K.A. Gavhane, "Chemical Reaction Engineering Volume I and Volume II", Nirali Prakashan, 2023														
2. Scott Fogler H., "Elements of Chemical Reaction Engineering", Fourth Edition, Prentice Hall of India, Eastern Economy Edition, New Delhi, 2008.														
3. Smith J.M., "Chemical Engineering kinetics", Third Edition, McGraw Hill, 1981.														
4. Miller G T, "Chemical Reaction Engineering", CBS Publisher, 2016.														
CO-PO MAPPING:														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and            Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	1	1	1	1	1	-	-	-	-	1	2	3
CO2	2	2	2	1	1	-	-	-	1	-	-	2	2	3
CO3	3	2	1	2	1	-	-	-	1	1	-	2	2	3
CO4	3	2	2	2	1	-	-	-	-	1	-	2	2	3
CO5	2	2	1	1	1	-	-	-	-	-	1	2	2	3



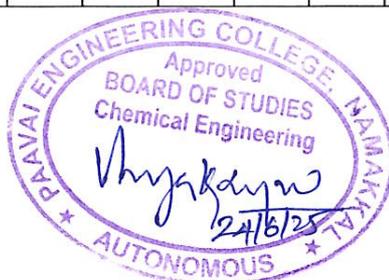
CM23503	MASS TRANSFER I			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	comprehend the fundamentals, types of diffusion and flux of mass transfer operations						
2	understand the theories of mass transfer and the concept of inter-phase mass transfer						
3	acquire basic concepts of humidification process and its application						
4	understand the types of dryers and mechanism of drying operations						
5	understand the concept of crystallization process and identification of suitable crystallizer						
<b>UNIT I</b>	<b>MOLECULAR DIFFUSION</b>						<b>9</b>
Introduction to mass transfer operations. Types of diffusion - Molecular and eddy diffusion, Flux, Fick's law, Effect of temperature and pressure in diffusivity. Steady state diffusion in gases, liquids. Diffusivity measurement and prediction in gases and liquids – Stefan tube, Twin bulb, Chapman and Enskog, diaphragm cell, Wilke chang; Diffusion in solids – Knudsen, Surface diffusion. Multi-component diffusion.							
<b>UNIT II</b>	<b>INTERPHASE MASS TRANSFER</b>						<b>9</b>
Concept of mass transfer coefficients, theories of mass transfer, relationship between individual and overall mass transfer coefficients. Analogies of mass transfer. Stage wise contacting equipment for gas-liquid operations – plate column – Sieve, valve; Packed column – regular and random packing; Factors affecting column performance and comparison.							
<b>UNIT III</b>	<b>HUMIDIFICATION OPERATIONS</b>						<b>9</b>
Humidification – Equilibrium, humidity chart, adiabatic and theory of wet bulb thermometry; humidification operations; theory and design of cooling towers, Equipments: Cooling tower – natural and forced draft, adiabatic humidification - spray chambers, spray ponds and dehumidification.							
<b>UNIT IV</b>	<b>DRYING</b>						<b>9</b>
Drying – Equilibrium. Types of moisture content, general drying behavior – theory of moisture movement in solids, theoretical estimation of drying rate and time. Continuous dryers – material and energy balance. Dryers classification based on solids handling and various types of dryer such as rotary, vacuum, spray, drum, fluidized bed - Advance drying techniques such as freeze drying, microwave drying.							
<b>UNIT V</b>	<b>CRYSTALLIZATION</b>						<b>9</b>
Crystal geometry. Equilibrium, yield and purity of products, theory of super saturation, nucleation and crystal growth, classification of crystallizers, Material balance equation for yield calculation, Crystallization equipment – Swenson walker, krystal, DTB and oslo.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to													<b>BT Mapped (Highest Level)</b>	
CO1	estimate the mass transfer flux for molecular diffusion in fluids and measurement of diffusivity.												Analyzing (K4)	
CO2	apply mass transfer theories to predict the mass transfer coefficients.												Applying (K3)	
CO3	formulate to solve material balances for cooling tower operations.												Analyzing (K4)	
CO4	apply the concept of drying operations in industrial applications.												Applying (K3)	
CO5	select suitable crystallizer and to solve material balances for crystallization operations.												Applying (K3)	
<b>TEXT BOOKS</b>														
1. Narayanan K.V. and Lakshmikutty, B “Mass Transfer – Theory and Applications”, 2 <sup>nd</sup> Edition, CBS Publishers & Distributors Pvt Ltd, New Delhi, 2023.														
2. Treybal, R. E., “Mass Transfer Operations”, 3rd Edition, McGraw-Hill, 2017.														
<b>REFERENCES</b>														
1. McCabe, W.L., Smith, J.C., and Harriot, P., “Unit Operations in Chemical Engineering”, 7 <sup>th</sup> Edition, McGraw-Hill, 2017.														
2. Coulson, J.M. and Richardson, J.F., “Chemical Engineering” Vol. I and II, 5 <sup>th</sup> Edition, Asian Books Pvt. Ltd., India, 2002.														
3. Anantharaman, N and Meera Sheriffa Begum, K. M. “Mass Transfer: Theory and Practices” Prentice Hall of India Pvt. Ltd, 2011.														
4. Dutta B K., “Principles of Mass Transfer and Separation Processes”, Prentice Hall India Learning Private Limited, 2006.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	-	-	-	-	-	-	3	2	3
CO2	3	3	3	-	-	-	-	-	-	-	-	3	2	3
CO3	3	3	3	-	-	-	-	-	-	-	-	3	2	3
CO4	3	3	3	-	-	1	1	1	-	-	-	3	2	3
CO5	3	3	3	-	-	1	-	1	-	-	-	3	2	3



CM23504	INSTRUMENTAL METHODS OF ANALYSIS	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the properties of electromagnetic spectrum, energy of molecules and the spectrum.				
2	learn basic idea, Principles and applications of infrared absorption spectroscopy.				
3	acquire knowledge on types of electronic transition in molecules.				
4	understand fundamental concepts and application of NMR and Mass spectroscopy.				
5	identify various chromatography methods.				
<b>UNIT I</b>	<b>INTRODUCTION TO SPECTROSCOPY</b>				<b>9</b>
General introduction – classification of instrumental methods – spectroscopy – properties of electromagnetic radiation – electromagnetic spectrum – different types of molecular energies – interaction of electromagnetic radiation with matter – origin of spectrum – the Jablonski diagram.					
<b>UNIT II</b>	<b>INFRARED ABSORPTION SPECTROSCOPY</b>				<b>9</b>
Introduction – The range of infrared radiation – Nomenclature of infrared spectra – Requirements for IR absorption – Instrumentation: Single and Double Beam Spectrophotometers – Mode of vibrations of atoms in polyatomic molecules – Factors influencing vibrational frequencies – Selection rules – Position and Intensity of bands – Applications of IR in organic compounds and inorganic complexes.					
<b>UNIT III</b>	<b>UV-VISIBLE SPECTROSCOPY</b>				<b>9</b>
Visible spectroscopy: Absorbance and transmittance – Beer and Lambert's laws – Deviations from Beer's law. Ultraviolet spectroscopy: Origin and Theory of UV spectra – Types of Transitions – The shape of UV absorption curves – Transition probability – Chromophore and related terms – Effect of conjugation – Solvent effects – Instrumentation – Single beam and double beam spectrophotometers and applications.					
<b>UNIT IV</b>	<b>NMR AND MASS SPECTROMETRY</b>				<b>9</b>
Nuclear Magnetic Resonance (NMR): Introduction to NMR – Equivalent and non-equivalent protons – Chemical shift – Position of PMR signals – Spin – spin coupling – Coupling constant – Instrumentation (proton NMR) – Solvents used in NMR – Interpretation of NMR spectra – Applications. Mass Spectrometry: Theory – components of mass spectrometer – General rules for Interpretation of mass spectra – Applications of mass spectra.					
<b>UNIT V</b>	<b>CHROMATOGRAPHIC METHODS</b>				<b>9</b>
Introduction – Theoretical principles – Types of chromatography: Principles, important components, mode of separations and applications of Paper chromatography – Thin Layer chromatography – Column chromatography – Gas chromatography – Ion exchange chromatography and High-Performance (Pressure) Liquid Chromatography (HPLC).					
<b>TOTAL PERIODS</b>					<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	explain the properties of electromagnetic radiations and interaction of the radiations with matters.	Analyzing (K4)												
CO2	interpret various absorption bands of IR spectra of chemical compounds.	Analyzing (K4)												
CO3	demonstrate types of electronic transition in molecules.	Applying (K3)												
CO4	analyze NMR and Mass spectra of organic compounds.	Analyzing (K4)												
CO5	perform separation of chemical compounds with appropriate chromatographic technique.	Analyzing (K4)												
<b>TEXT BOOKS</b>														
1. Gurdeep R. Chatwal Shan K Anand, "Instrumental methods of Chemical Analysis", 5 <sup>th</sup> Edition, Himalaya Publishing House, New Delhi, 2022.														
2. Muralidharan Rao. D., Swamy A.V.N, Dharaneeswaran Reddy D, "Instrumental Method of Analysis", CBS Publishers and Distributors, 2013.														
<b>REFERENCES</b>														
1. Skoog D.A and West D.M "Fundamental of Analytical Chemistry", 7 <sup>th</sup> edition, Saunders college publishing, New York, 1996.														
2. Willard H.H., Merritt L.L., Dean J.A., and Settle F.A., "Instrumental Methods of Analysis", 7 <sup>th</sup> Edition, C B S Publishers & Distributors, Delhi, 2004.														
3. Daniel C. Harris, "Qualitative chemical analysis", 9 <sup>th</sup> Edition, W. H. Freeman and Company, New York, 2015.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1	1	2	1	1	-	1	-	-	1	2	3
CO2	2	2	2	2	1	-	-	-	1	-	-	2	2	3
CO3	3	2	1	2	2	-	-	1	1	1	-	2	2	3
CO4	3	3	2	2	3	-	-	-	1	1	-	2	2	3
CO5	2	2	1	1	1	-	-	-	-	-	1	2	2	3



CM23505	TECHNICAL ANALYSIS LABORATORY			0	0	4	2
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	analyze the different fuel analysis studies and viscosity of lube oil						
2	determine the chemical contents present in soap and shampoo, bleaching powder						
3	estimate the contents of oil and cement						
4	analyse the contents in fruit juice, soft drinks, milk, honey and turmeric powder						
<b>LIST OF EXPERIMENTS</b>							
1. Determination of Viscosity index of lubricating oils							
2. Determination of flash and fire point of fuels							
3. Determination of cloud, pour and aniline point of fuels							
4. Analysis of Bleaching powder							
5. Soap and/or Shampoo Analysis							
6. Oil Analysis							
7. Cement Analysis							
8. Analysis of fruit juice and/or soft drinks							
9. Analysis of milk and/or vinegar							
10. Analysis of Honey and/or Edible oil							
11. Analysis of turmeric powder							
12. Conductometry titration							
						<b>TOTAL PERIODS</b>	<b>60</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	estimate the characteristics of fuels					analyzing (K4)	
CO2	determine total fatty acid, alkali content of soap, available chlorine in bleaching powder					analyzing (K4)	
CO3	estimate the silica, mixed oxide and calcium oxide content in cement and free acid, saponification value, iodine value of oil					analyzing (K4)	
CO4	analyze the milk, honey, soft drinks and turmeric powder for their contents.					analyzing (K4)	

**CO-PO MAPPING :****Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)****(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak**

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	1	2	1	-	-	-	-	2	2	3	3
CO2	2	1	3	-	2	1	-	-	-	-	1	2	3	3
CO3	3	2	2	1	2	1	-	-	-	-	1	2	3	3
CO4	2	2	2	1	2	1	-	-	-	-	1	2	3	3



CM23506	INDUSTRIAL TRAINING			0	0	2	1
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	provide students with hands-on experience in a real-world industrial environment						
2	facilitate the development of professional skills and competencies, including communication, teamwork, and problem-solving						
3	allow students to explore their career interests and gain insights into potential career paths in their field of study						
4	enhance students' understanding of industry standards, practices, and expectations through direct interaction and feedback from industry professionals						
<b>DESCRIPTION</b>							
<p>Industrial Training provides work experience relevant to their field of specialization, before graduation, and it is an essential component for the development of practical and professional skills required for an engineering graduate and supports for prospective employment.</p> <p>At the end of the industrial training, students should be able to improve their knowledge and skills relevant to their areas of specialization where they have been trained. The students should also be able to relate, apply, and adapt the relevant knowledge, concepts, and theories within an industrial organization, and also to practice the general workplace behavior and interpersonal skills.</p> <p>The student (either in group or single) should undergo industrial training for a minimum period of two weeks during the summer vacation after the completion of fourth semester as specified in the curriculum in any research organization/university/industry of State/National and International level industry relevant to their branch of specialization, after getting proper approval from the Head of the Institution.</p> <p>On the completion of the industrial training for the specified period, the student has to submit the industrial training report (at least 25-30 pages) containing the following details, along with the certificate obtained from the industry for the period of training undergone.</p> <ol style="list-style-type: none"> <li>1. Introduction of the industry.</li> <li>2. Industry layout and its various operations with its infrastructure facilities.</li> <li>3. Formulation of practical problems, data required to formulate the problems and its analysis.</li> <li>4. Suggestions and recommendations for the above problems</li> </ol> <p>During the period of training, the student has to abide the rules and regulations enforced by the organization and to ensure FULL attendance during the period of industrial training and uphold the discipline and decorum of the institution.</p>							

On the completion of the industrial training, the End Semester Examinations shall be conducted by the Office of the Controller of Examinations at the end of the fifth semester. A three-member committee constituted by the Head of the Institution, consisting of (1) a senior faculty member at the Professor level, (2) senior faculty member at the Associate Professor and (3) faculty member from outside the department, will evaluate the industrial training undergone by the student. The evaluation shall be made based on the report submitted along with the presentation and a Viva voce Examination.

		<b>TOTAL PERIODS :30</b>
<b>COURSE OUTCOMES</b>		<b>BT MAPPED</b>
At the end of the course, the students will be able to		(Highest level)
CO1	plant layout, machinery, organizational structure and production processes in the firm or research facilities in the laboratory/research institute	Analysing (K4)
CO2	analysis of industrial / research problems and their solutions	Analysing (K4)
CO3	documenting of material specifications, machine and process parameters, testing parameters and results	Remembering (K1)
CO4	preparing of Technical report and presentation	Understanding (K2)

**CO - PO MAPPING**

Mapping of Course Outcomes with Programme Outcomes:

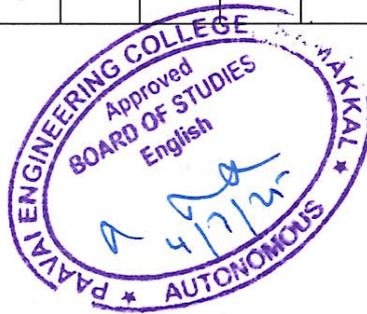
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	-	-	-	-	-	-	-	2	1	3
CO2	1	-	-	-	-	-	-	-	-	-	-	2	1	3
CO3	2	2	-	-	-	-	-	-	-	-	-	3	2	3
CO4	3	2	2	2	2	-	-	-	-	-	-	3	3	3



GE23501	PROFESSIONAL DEVELOPMENT III	0	0	2	1
<b>COURSE OBJECTIVES</b>					
To enable students to					
1.	enhance their Resume writing skills and improving corporate vocabularies to survive in the corporate world.				
2.	evaluate their interview skills and improve their interview presentation.				
3.	solve the quantitative aptitude problems and improve their mental ability.				
4.	improve critical thinking and reasoning skills.				
<b>UNIT I</b>	<b>RESUME WRITING SKILLS</b>				<b>6</b>
Updated Resume Building III – Self Introduction III – Dressing Etiquette – JAM V – Corporate Vocabulary.					
<b>UNIT II</b>	<b>INTERVIEW SKILLS</b>				<b>6</b>
Interview skills – General guidelines - Work Ethics – Group Discussion III – JAM VI – Presentation Competence – Mock Interview.					
<b>UNIT III</b>	<b>QUANTITATIVE APTITUDE</b>				<b>9</b>
Cube Root and Square Root - Time and Work - Ages - Permutation and Combination - Probability – Calendar.					
<b>UNIT IV</b>	<b>LOGICAL REASONING</b>				<b>9</b>
Series Completion - Blood Relations - Coding and Decoding - Data Sufficiency - Statements and Assumptions.					
<b>TOTAL PERIODS:</b>					<b>30</b>
<b>COURSE OUTCOMES</b>					<b>BT MAPPED</b>
Upon completion of the course, the students will be able to					(Highest Level)
<b>CO1</b>	excel in drafting Resumes and speaking.				Applying (K3)
<b>CO2</b>	demonstrate the participative skills in group discussions and Interviews.				Applying (K3)
<b>CO3</b>	solve problems based on quantitative aptitude.				Applying (K3)
<b>CO4</b>	enhance their logical and verbal reasoning.				Analyzing (K4)
<b>TEXTBOOKS</b>					
1. Aggarwal, R. S. A Modern Approach to Verbal & Non-Verbal Reasoning, Revised ed., 2024–25, S. Chand & Company Ltd., 2024.					
2. Aggarwal, R. S. Objective General English: Fully Revised Video Edition. S. Chand & Company Ltd., 2022.					
<b>REFERENCES</b>					
1. Abhijit Guha, "Quantitative Aptitude ", Tata-Mcgraw Hill.2015.					
2. Word Power Made Easy By Norman Lewis, Wr.Goyal Publications.2016.					
3. Johnson, D.W. Reaching out — Interpersonal Effectiveness and self- actualisation. Boston: Allyn and Bacon.2019.					
4. Infosys Campus Connect Program — students' guide for soft skills.2015.					

CO/PO MAPPING:														
Mapping of Course Outcome (CO's) with Programme Outcomes (PO's) (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	Programme Outcomes (PO's)													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PS01	PS02
CO1	3	2	2	3	3	1	-	-	-	-	-	-	3	2
CO2	-	2	3	-	2	-	2	-	-	-	-	-	3	2
CO3	3	2	2	2	-	-	1	-	-	-	-	-	2	3
CO4	3	2	2	-	-	1	-	-	-	-	2	-	2	3



CM23151	OIL AND NATURAL GAS ENGINEERING			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	know the origin, reservoirs and exploration methods						
2	understand drilling methods, rigs and platforms						
3	learn about the enhanced oil recovery methods.						
4	acquire knowledge on natural gas extraction, storage and transportation.						
5	learn the oil spill management systems						
<b>UNIT I</b>	<b>PETROLEUM ORIGIN EXPLORATION</b>						<b>9</b>
Origin –Theories of petroleum occurrence – Types of reservoirs - Source, cap and reservoir rocks - Oil bearing rocks - Migration and accumulation of Petroleum. Petroleum exploration methods - Geological exploration methods – Geophysical exploration methods – Geochemical methods							
<b>UNIT II</b>	<b>DRILLING METHODS</b>						<b>9</b>
Drilling method, Drilling fluids function and properties, Packer fluid – Casing packs – Cementing – Various well completion methods, Drilling problems, their control and remedies – Various stimulation methods. Various types of onshore and offshore rigs and platforms							
<b>UNIT III</b>	<b>ENHANCED OIL RECOVERY TECHNIQUES</b>						<b>9</b>
Basic principles and mechanism of EOR, Concept of pattern flooding, recovery efficiency. Primary, secondary and enhanced oil recovery techniques and methods – Major well complication and Remedies. EOR methods: Chemical flooding, Miscible flooding, Thermal recoveries.							
<b>UNIT IV</b>	<b>NATURAL GAS</b>						<b>9</b>
Properties of Natural Gases: typical compositions. Shale gas extraction. Compression and liquefaction of natural gas, Storage and transportation of natural gas application in chemical process, industrial and transportation sector.							
<b>UNIT V</b>	<b>SAFETY REGULATIONS</b>						<b>9</b>
Safety in oil spill management – prevention and clean up technologies - Alaska and gulf of Mexico case studies. Safe storage and transportation of petroleum and petroleum products.							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	explain the basics of crude origin, reservoir and its exploration					Analyzing (K4)	
CO2	study the basics of the drilling techniques and rigs					Applying (K3)	
CO3	analyze enhanced oil recovery methods					Analyzing (K4)	

CO4	know natural gas extraction and its storage.	Understanding (K2)
CO5	understand the oil spill management system	Applying (K3)

**TEXT BOOKS**

1. Bhagwan Sahay “Petroleum Exploration and Exploitation Practices” Allied Publishers Ltd., Chennai, 1994.
2. Frank Jahn, Mark Cook, Mark Graham, “Hydrocarbon Exploration and Production”, 2nd edition, Elsevier Science, 2008.

**REFERENCES**

1. M. Rafiqul Islam, J.H. Abou-Kassem, S.M. Farouq-Ali, “Petroleum Reservoir Simulation: The Engineering Approach”, Gulf Professional Publishing, 2020.
2. Havard Devold, “Oil and gas production handbook, An introduction to oil and gas production, transport, refining and petrochemical industry”, 2015.
3. B. Guo, W.C. Lyons and A. Ghalambor, Petroleum Production Engineering: A Computer Assisted Approach, Elsevier, 2007.
4. T. Ahmed and P. D. McKinney, “Advanced Reservoir Engineering”, Elsevier, 2005.

**CO-PO MAPPING :**

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2	1	-	2	1	-	-	1	-	-	1	2
CO2	3	2	2	1	-	2	1	-	-	-	-	-	1	2
CO3	3	2	1	1	-	2	1	-	-	-	-	-	2	2
CO4	3	2	2	-	-	2	1	-	--	-	-	1	2	2
CO5	2	2	1	1	1	2	1	-	-	-	-	1	2	2



CM23152	<b>PETROLEUM REFINING I</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn the crude characteristics and its Thermophysical properties						
2	examine how each petroleum product tests						
3	learn crude processing to achieve the objectives of each refinery process.						
4	learn the different finishing processing techniques.						
5	understand the lube oil and bitumen processing techniques.						
<b>UNIT I</b>	<b>INTRODUCTION TO PETROLEUM REFINING</b>						<b>9</b>
Crude Oil origin, Types of crudes & composition. Characteristics of crude oil, Classification of hydrocarbons. Physical and Thermophysical Properties of Petroleum Fractions. Refineries in India – crude availability vs demands.							
<b>UNIT II</b>	<b>TESTING OF PETROLEUM PRODUCTS</b>						<b>9</b>
Petroleum products – composition, properties, uses – LPG, Naptha, Motor spirit, Kerosene, ATFs, Diesel, Fuel Oil, Lubricating oils, Petroleum Waxes, Bitumens and Petroleum Coke. Bharath stage III, IV Norms for fuels. Euro Stage IV, V, VI norms for fuels.							
<b>UNIT III</b>	<b>CRUDE PROCESSING</b>						<b>9</b>
Dehydration and Desalting - Types of salt in crude, Desalting process – electrical desalting, Preheating - furnace and its operation. Atmospheric distillation – process variables, typical yield pattern, Vacuum distillation of reduced crude oil, Operation of fractionating columns – types of trays, flow pattern, reflux types and its significance. Stability of column operation							
<b>UNIT IV</b>	<b>FINISHING PROCESSES</b>						<b>9</b>
Hydrogen sulphide removal processes – Absorption and adsorption, Sulphur conversion process – claus, selective oxidation, thermal cracking of H <sub>2</sub> S – Sweetening processes – Copper chloride, Merox processes and clay treatment. Solvent extraction and hydrotreating for desulphurization.							
<b>UNIT V</b>	<b>LUBE OIL AND BITUMEN MANUFACTURING PROCESS</b>						<b>9</b>
Vacuum residue properties- propane deasphalting-asphalt processing and types-air blowing of bitumen- Solvent dewaxing process - wax and types, properties- wax deoiling, sweating, hydro treating of wax- molding and storage. Solvent extraction of lube oil fractions							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	know crude oil supply and demand, different refinery feedstocks and products, and study quality testing methods.					Understanding (K2)	

CO2	apply the petroleum products testing including Bharat standards.	Applying (K3)
CO3	analyze crude distillation unit operating atmospheric and vacuum conditions.	Analyzing (K4)
CO4	explain the Sulphur removal techniques.	Understanding (K2)
CO5	demonstrate asphalt and wax processing technology	Understanding (K2)

#### TEXT BOOKS

1. Modern Petroleum Refining Processes, BK Bhaskara Rao, Oxford & IBH Publishing Co. Pvt. Ltd. ISBN 8120417151, 9788120417151.
2. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2000, ISBN1683921062, 9781683921066.

#### REFERENCES

1. M.A. Fahim, T.A. Al-sahhaf, A.S. Elkilani, "Fundamentals of Petroleum Refining", Elsevier Science and Technology, 2010, ISBN 978-0-444-52785.
2. J.G. Speight and B. Ozum, "Petroleum Refining Processes", Marcel Dekker Inc, New York, 2002.
3. G.D. Hobson, "Modern Petroleum Technology", Vol I & II, John Wiley & Sons, New York, 5th edition, 1984.
4. David.S.J., STAN Jones and Peter R. Pujado "Handbook of Petroleum Processing, Springer, 2006.

#### CO-PO MAPPING :

Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	2	1	-	1	1	-	2	1	-	-	1	1
CO2	2	1	2	1	-	1	2	-	-	-	-	-	1	1
CO3	3	2	2	1	1	1	1	-	-	-	-	-	2	2
CO4	2	1	2	-	1	1	2	1	-	-	-	-	1	1
CO5	2	1	2	-	-	1	2	-	-	-	1	-	2	1



CM23153	PETROLEUM REFINING II			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn the methodologies in the secondary petroleum refining or upgrading processes like thermal cracking, coking,						
2	learn catalytic cracking processes on FCC						
3	learn hydrocracking, hydrotreating processes						
4	learn refinery operations on Vis breaker, DCU, Reformer, etc.						
5	understand reforming, isomerisation and alkylation process						
<b>UNIT I</b>	<b>THERMAL CRACKING AND COKING</b>						<b>9</b>
Residue upgradation technologies- cracking-thermal cracking-mechanism, principle, reactions - process variables- Visbreaking- soaker process- coil visbreaker – Disadvantages – Mechanism of coking- delayed coking-operation-fluid coking- flexi coking-types of coke and properties- yield pattern of cracking and coking, coke applications.							
<b>UNIT II</b>	<b>CATALYTIC CRACKING</b>						<b>9</b>
Principles of catalytic cracking-mechanisms- FCC- main reaction of FCC- role of FCC in refinery- Fluidization- feedstocks, products, yield pattern - Catalytic cracking – reaction, regeneration, fractionation sections.							
<b>UNIT III</b>	<b>HYDRO CRACKING AND HYDROTREATING</b>						<b>9</b>
Hydrocracking process- Typical hydrocracker in refinery- types, reactions, catalyst, conversion, Temperature profile for yield pattern- Operation and variables. Hydro treatment - H <sub>2</sub> requirements - steam reforming and shift conversion-operation and Nickel catalyst.							
<b>UNIT IV</b>	<b>CATALYTIC REFORMING</b>						<b>9</b>
Reforming reactions, catalysts, process variables, yield in reforming technologies - platforming reactions –Houdri forming, Rhein forming, Power forming, Selecto forming, Ultra forming and Rex forming. Catalytic reforming for aromatics production.							
<b>UNIT V</b>	<b>ALKYLATION AND ISOMERISATION</b>						<b>9</b>
Feed Stocks and Reactions for Alkylation Process- Cascade Sulphuric Acid Alkylation, Hydrofluoric Acid Alkylation. Isomerization Process- Isomerization with Platinum Catalyst and Aluminium Chloride Process.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	explain the different thermal cracking techniques and its applications	Understanding (K2)
CO2	demonstrate the reactions and mechanism involved in FCC	Understanding (K2)
CO3	analyse the hydrogen requirements in refineries and learn the methods of hydrogen production.	Analyzing (K4)
CO4	explain the technologies involved in reforming	Understanding (K2)
CO5	explain the isomerisation and alkylation processes.	Understanding (K2)

#### TEXT BOOKS

1. BK BhaskaraRao, "Modern Petroleum Refining Processes", Oxford & IBH Publishing Co. Pvt. Ltd. ISBN 8120417151, 9788120417151.
2. Prasad, R., "Petroleum Refining Technology", Khanna Publishers, New Delhi, 2020, ISBN 1683921062, 9781683921066.

#### REFERENCES

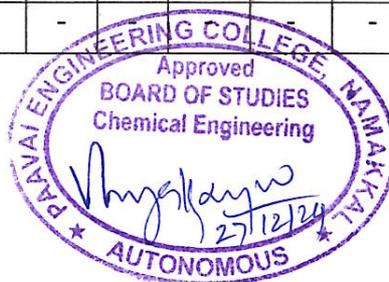
1. J.G. Speight and B. Ozum, "Petroleum Refining Processes", Marcel Dekker Inc, New York, 2002.
2. G.D. Hobson, "Modern Petroleum Technology", Vol I & II, John Wiley & Sons, New York, 5th edition, 1984.
3. David.S.J." STAN" Jones and Peter R.Pujado "Handbook of Petroleum Processing, Springer, 2006, ISBN 978-1-4020-2820-5.
4. M.A. Fahim, T.A. Al-sahhaf, A.S. Elkilani, "Fundamentals of Petroleum Refining", Elsevier Science and Technology, 2010, ISBN 978-0-444-52785.

#### CO-PO MAPPING :

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)**

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	2	1	1	-	-	-	2	1	1	2	2	2
CO2	2	2	1	1	-	-	2	-	-	-	-	-	2	1
CO3	2	1	1	1	-	2	1	-	-	-	-	-	2	2
CO4	2	2	1	1	-	-	-	-	-	-	-	-	2	2
CO5	2	1	1	1	-	-	-	-	-	-	-	-	1	1



CM23154	PETROCHEMICAL DERIVATIVES			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	study the process and production of different chemicals from crude oil.						
2	learn the operation and methodologies in petrochemical industries.						
3	know the application of petrochemicals in all process fields						
4	learn each product of petrochemical industries						
5	understand application with production techniques in detail.						
<b>UNIT I</b>	<b>PRECURSORS</b>						<b>9</b>
Alternate routes with flow diagram for production of methane, ethane, propane, ethylene, propylene, butylenes, acetylene, naphthalene.							
<b>UNIT II</b>	<b>FIRST GENERATION PETROCHEMICALS</b>						<b>9</b>
Alternate routes with flow diagram for production of butadiene, related dienes, aromatics – Benzene, toluene, xylene and their derivatives							
<b>UNIT III</b>	<b>SECOND GENERATION PETROCHEMICALS</b>						<b>9</b>
Alternate routes with flow diagram for production of ethylene glycol, VCM, acrylonitrile, phenol, caprolactum, adipicacid, hexmethylenediamine, DMT, TPA, maleic anhydride, styrene.							
<b>UNIT IV</b>	<b>THIRD GENERATION PETROCHEMICALS</b>						<b>9</b>
Polymerization – Modes and techniques – Production of polyethylene – LDPE, HDPE, polypropylene, poly butadiene rubber, SBR, polystyrene, SAN, ABS.							
<b>UNIT V</b>	<b>GLOBAL CHEMICALS</b>						<b>9</b>
Petrochemicals-Lubricants, additives, adhesives, agrochemicals, cosmetics raw materials, electronic chemicals, detergents, paint, healthcare and pharmaceuticals, Fertilizers-Ammonia, Urea, NPK, decarbonisation, net zero carbon.							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	apply the basic knowledge of the petrochemical industry and its growth, history					Applying (K3)	
CO2	classify different intermediates for petrochemical industries					Applying (K3)	
CO3	analyze different complex petrochemicals along with their applications.					Analyzing (K4)	
CO4	analyze the supply and demand of polymers and to study different polymer production technologies.					Analyzing (K4)	

CO5	explain the global petrochemical market.	Understanding (K2)												
<b>TEXT BOOKS</b>														
1. Bhaskara Rao, B.K. "A Text on Petrochemicals", 2nd Edition, Khanna Publishers, New Delhi, 2004, ISBN 8174090444														
2. Wiseman .P., "Petrochemicals", UMIST Series in Science and Technology, John Wiley & Sons, 1986, ISBN 13: 9780853127413														
<b>REFERENCES</b>														
1. A. Chawvel and G. Lefebvre, "Petrochemical Process", Vol. I & II, Gulf Publishing Co., Houston, London, 1989, ISBN 0872017729, 9780872017726														
2. Brownstein A.M. 'Trends in Petrochemical Technology', Petroleum Publishing Company, 1976.														
3. G.Margaret Wells, 'Handbook of Petrochemicals and Processes' 2nd Revised Edition, Gower Publishing Company, 2018.														
4. Robert A. Meyers, "Handbook of Petrochemicals Production Processes", McGraw-Hill Education: New York, 2nd edition, 2019 (ISBN: 9781259643132)														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	2	1	2	2	1	-	2	-	1	-	2	2
CO2	2	2	2	1	-	-	-	-	-	-	-	-	2	2
CO3	2	2	1	1	-	-	-	-	-	-	-	-	2	2
CO4	2	2	2	1	-	-	-	-	-	-	-	-	2	2
CO5	1	2	1	1	1	-	-	-	3	-	2	1	2	2



CM23155	PETROLEUM CORROSION TECHNOLOGY	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	understand the basic concepts of corrosion and its impacts.					
2	understand the various types of corrosion in in petroleum processes.					
3	gain knowledge on removal techniques of various gases in pipelines applications.					
4	understand the corrosion preventing methods					
5	evaluate the corrosion rate and propose the protection method based on environmental considerations.					
<b>UNIT I</b>	<b>BASICS OF PETROLEUM CORROSION</b>				<b>9</b>	
Introduction to corrosion control. Definitions - Materials involved - Basic corrosion principles - corrosion rate. Electrochemical reactions. Electrode potentials – passivity – temperature – pressure – velocity – conductivity - pH - dissolved gases. Corrosion in oil and gas production.						
<b>UNIT II</b>	<b>FORMS OF CORROSION</b>				<b>9</b>	
Forms of corrosion – uniform corrosion – Pitting - Galvanic corrosion - Intergranular and weld corrosion - Selective Leaching - Stress corrosion. Impingement - Hydrogen embrittlement – Corrosion fatigue.						
<b>UNIT III</b>	<b>CORROSIVE ENVIRONMENTS</b>				<b>9</b>	
Role of oxygen in oil filed corrosion- down hole and surface equipment - water flood. Removal of oxygen, analysis and criteria for control. Role of carbon dioxide (CO <sub>2</sub> ) in corrosion - Effect of temperature and pressure - Corrosion of well tubing and other equipments. Role of hydrogen sulphide (H <sub>2</sub> S)-Corrosion in downhole, surface, storage and pipelines.						
<b>UNIT IV</b>	<b>CORROSION CONTROL</b>				<b>9</b>	
Corrosion prevention methods - Principles of operation and applications systems. Cathodic protection – Galvanic systems - Corrosion prevention coatings- Corrosion prevention inhibitors types of corrosion inhibitors- Inhibitor selection and injection						
<b>UNIT V</b>	<b>CORROSION MONITORING</b>				<b>9</b>	
Inspection and corrosion monitoring. Oil treatment corrosion - crude oil properties – desalting - sweetening processes. Corrosion in oil storage tank corrosion- oil field and oil treating facilities - oil, gas pipelines -offshore platforms- subsea systems.						
					<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	understand the basic concepts of corrosion and its impacts.	Applying (K3)												
CO2	understand the various types of corrosion in petroleum processes.	Understanding (K2)												
CO3	gain knowledge on removal techniques of various gases in pipelines applications.	Applying (K3)												
CO4	understand the corrosion preventing methods	Analyzing (K4)												
CO5	evaluate the corrosion rate and propose the protection method based on environmental considerations.	Analyzing (K4)												
<b>TEXT BOOKS</b>														
1. "Corrosion control in Petroleum production"-TPC 5-2-nd edition H.G.Byars NACE International, 1999.														
2. Chemical engineering series, coulson and Richardson, Mc Graw Hill Publications.														
<b>REFERENCES</b>														
1. Standard Handbook of Petroleum and Natural Gas Engineering. 2nd Edition. William C Lyons, Gary C Plisga. Gulf Professional Publishing.														
2. G.Margaret Wells, 'Handbook of Petrochemicals and Processes' 2nd Revised Edition, Gower Publishing Company, 2018.														
3. Robert A. Meyers, "Handbook of Petrochemicals Production Processes", McGraw-Hill Education: New York, 2 nd edition, 2019 (ISBN: 9781259643132)														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	2	1	2	2	1	-	2	-	1	-	2	2
CO2	2	2	2	1	-	3	2	-	-	-	-	-	2	2
CO3	2	2	1	1	-	3	2	-	-	-	-	-	2	2
CO4	2	2	2	1	-	3	2	-	-	-	-	-	2	2
CO5	1	2	1	1	1	3	2	-	3	-	2	1	2	2



CM23156	POLYMER TECHNOLOGY			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	know basic concepts of macromolecules, functionality and degree of polymerization.						
2	learn addition and condensation polymerizations						
3	compute molecular weight averages from the molecular weight distribution,						
4	understand the glass transition temperature in polymers.						
5	learn various plastic moulding techniques.						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Basic concepts of macromolecules – Monomers – Polymers – Natural and Synthetic polymers - structure of natural products like cellulose, rubber and proteins - Chemistry of Olefins and Dienes – double bonds - Functionality - degree of polymerization-Classification and nomenclature of polymers – Thermoplastic and thermosetting polymerization.							
<b>UNIT II</b>	<b>POLYMERIZATION SYNTHESIS</b>						<b>9</b>
Addition Polymerization: free radical polymerization – cationic polymerization – anionic polymerization – coordination polymerization – industrial polymerization – bulk, emulsion, suspension and solution polymerization techniques – Copolymerization concepts – Condensation polymerization.							
<b>UNIT III</b>	<b>MOLECULAR WEIGHTS OF POLYMERS</b>						<b>9</b>
Molecular weight of polymer: Number average and Weight average molecular weights – Degree of polymerization – molecular weight distribution – Polydispersity – Molecular weight determination.– Gel Permeation Chromatography, Osmometry and Light Scattering.							
<b>UNIT IV</b>	<b>GLASS TRANSITIONS TEMPARATURE</b>						<b>9</b>
Glass transition Temperature: significance and experimental study – Melting Point of polymer - significance and experimental study – Relationship between Tg and Tm – Crystallinity in polymers – effect of crystallization– factors affecting crystallization - Polymer Density, Apparent Density, Viscosity measurements.							
<b>UNIT V</b>	<b>PLASTICS PROCESS – MOULDIG TECHNIQUES</b>						<b>9</b>
Injection molding: Principle, Types and advantages - Blow molding: Principle, Types and advantages - Thermoforming: Principle, Types and advantages - Compression molding: Principle, Types and advantages - Extrusion: Principle, Types and advantages – Calendaring: Principle, Types and advantages.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to													<b>BT Mapped (Highest Level)</b>	
CO1	explain the fundamentals of Monomer, Polymer and its types.												Understanding (K2)	
CO2	demonstrate the addition and condensation polymerization mechanism.												Applying (K3)	
CO3	explain on molecular weight and its significance												Understanding (K2)	
CO4	distinguish glass transition temperature and melting point												Applying (K3)	
CO5	analyze different molding techniques for different applications												Analyzing (K4)	
<b>TEXT BOOKS</b>														
1. Billmeyer.F.W.,Jr, Text Book of Polymer Science, Ed. Wiley-Interscience, 1984.														
2. Seymour. R.B., and Carraher.C.E., Jr., Polymer Chemistry, 2nd Ed., Marcel Dekker, 1988.														
<b>REFERENCES</b>														
1. Gowariker.V.T.,Viswanathan.N.V., and Sreedar.J., Polymer Science, Wiley Eastern Ltd., 1988.														
2. Joel,R.F; Polymer Science and Technology, Eastern Economy Edition, 1999.														
3. Rodriguez, F., Cohen.C.,Oberic.K and Arches, L.A., Principles of Polymer Systems, 6th edition, CRC Press, 2014.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
<b>(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak</b>														
	<b>PO's</b>												<b>PSO's</b>	
<b>CO's</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>1</b>	<b>2</b>
<b>CO1</b>	3	1	1	1	-	-	-	-	-	-	-	-	2	2
<b>CO2</b>	3	2	2	2	1	-	2	-	-	-	-	3	2	2
<b>CO3</b>	2	3	1	3	3	1	-	-	-	-	-	1	2	2
<b>CO4</b>	2	2	1	3	2	1	-	-	-	-	-	3	2	2
<b>CO5</b>	2	2	2	2	1	-	2	-	-	2	-	2	2	2



CM23157	PROCESS SAFETY IN PETROCHEMICAL INDUSTRIES	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	understand about the various classes of petrochemical products.					
2	know about different aspects of pipeline constructional safety aspects of oil transportation.					
3	obtain knowledge about various safety techniques of safe handling of hydro carbon.					
4	analyze different aspects of disaster management plans and safety management drill.					
5	understand about the various rules and regulations of petroleum industries.					
<b>UNIT I</b>	<b>PETROLEUM PRODUCTS CLASSIFICATION &amp; HAZARDS</b>				<b>9</b>	
Petroleum and Petroleum products – Fuels- Petroleum solvents – Lubricating oils – Petroleum wax, greases – Miscellaneous product.						
<b>UNIT II</b>	<b>UPSTREAM &amp; DOWNSTREAM OPERATION</b>				<b>9</b>	
On and off shore oil operation – Construction of Installation – Pipe line Construction – Maintenance and repair activities – Safety and associated hazards - transportation - Petroleum product storage.						
<b>UNIT III</b>	<b>SAFETY HANDLING OF HYDROCARBON</b>				<b>9</b>	
Boil over phenomena - Hydro Carbon Detector (HCD) – Remote Operated Shut Off valves (ROSOV) – Firefighting techniques – Foam types – AFFF, ARAFFF, and Rim Seal Fire Protection System - Foam Pourer – Foam monitor – Medium Expansion Foam Generator (MEFG), High Volume Long Range (HVLR) Monitor.						
<b>UNIT IV</b>	<b>DISASTER MANAGEMENT PLAN</b>				<b>9</b>	
Basics of major DMP - Objective of DMP - Categories of Emergencies – Quantitative Risk Assessment - Element of Disaster Management Plan - Mutual aid - On-site drill - Off-site drill - Disaster Management Act, 2005.						
<b>UNIT V</b>	<b>RULES AND REGULATION</b>				<b>9</b>	
Oil Industry Safety Directorate – OISD-STD-105 - OISD-STD-118 - OISD-STD-144 - Jaipur Fire Incident - OISD-STD-244 - The Petroleum Rules, 2002.						
					<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>						
At the end of this course, students will be able to					<b>BT Mapped (Highest Level)</b>	
CO1	explain about the various classes of petrochemical products.				Analyzing (K4)	
CO2	explore about different aspects of pipeline constructional safety aspects of oil transportation.				Applying (K3)	
CO3	analyze knowledge about various safety techniques of safe handling of				Applying (K3)	

	hydro carbon.													
CO4	gain different aspects of disaster management plans and safety management drill.	Applying (K3)												
CO5	about the various rules and regulations of petroleum industries.	Understanding (K2)												
<b>TEXT BOOKS</b>														
1. Abdul Khalique, “Basic Offshore Safety: Safety induction and emergency training for new entrants to the offshore oil and gas industry”, Routledge, 2017.														
2. Ian Sutton, “Offshore Safety Management”, 2nd Edition, 2013.														
<b>REFERENCES</b>														
1. Safety of offshore oil and gas operations: Lessons from past accident analysis, JRC Scientific and Policy reports.														
2. Michalis Christou and Myrto Konstantinidou, “Guide to the Offshore Installations (Safety Case) Regulations 2005”, HSE, 2012.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO’s) with Programme Outcomes (PO’s) and  Programme Specific Outcomes (PSO’s)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO’s	PO’s												PSO’s	
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CO1	3	2	1	1	2	1	1	-	1	-	-	1	2	3
CO2	2	2	2	2	1	-	-	-	1	-	-	2	2	3
CO3	3	2	1	2	2	-	-	1	1	1	-	2	2	3
CO4	3	3	2	2	3	-	-	-	1	1	-	2	2	3
CO5	2	2	1	1	1	-	-	-	-	-	1	2	2	3



CM23251	AIR POLLUTION ENGINEERING	3	0	0	3
<b>COURSE OBJECTIVES</b>					
The students will be able to					
1	understand the regulatory framework and standards for air quality and pollution control.				
2	learn the principles and design of equipment for controlling gaseous pollutants through absorption, adsorption, and incineration.				
3	understand mechanisms and technologies for particulate air pollution control.				
4	know the methods for controlling various air pollutants, including VOCs, HCs, sulfur oxides, nitrogen oxides, and mobile source pollutants.				
5	learn and apply air pollution dispersion models and meteorological factors affecting air quality.				
<b>UNIT I</b>	<b>INTRODUCTION</b>				<b>9</b>
Introduction to Air Quality; An Overview of the Clean Air Act Amendments; Air Pollution Regulatory Framework - Regulatory System – Laws and Regulations – Clean air Act – Provisions for Recent Developments. Ambient Air Quality Standards in India; Properties of Air Pollutants; Sources and effects of air pollution, emission standards, Air Quality Index.					
<b>UNIT II</b>	<b>GASEOUS POLLUTANTS</b>				<b>9</b>
Absorption- Principles, Description of equipment-Packed and Plate columns -Design and Performance equations; Adsorption- Principle Adsorbents, Equipment descriptions - PSA - Adsorption cycle - Solvent recovery system-Continuous Rotary bed, Fluidized bed, Design and Performance equations ; Incinerators, Hydrocarbon incineration kinetics- Equipment description- Design and Performance equations.					
<b>UNIT III</b>	<b>PARTICULATE POLLUTION CONTROL</b>				<b>9</b>
Particle Collection mechanisms– Fluid particle Dynamics – Particle size Distribution – Efficiency – Gravity Settling chambers Cyclones- Electrostatic precipitators and Bag houses.					
<b>UNIT IV</b>	<b>AIR POLLUTION MODELLING</b>				<b>9</b>
Meteorology and winds- Stability of the atmosphere, lapse rates & inversions- Air pollution dispersion models, Gaussian equation and variation, Industrial Air Pollution Sources and Prevention.					
<b>UNIT V</b>	<b>AIR POLLUTION CONTROL</b>				<b>9</b>
Principles of Pollution Prevention- Characteristics and control of VOCs and HCs, Characteristics and control of sulphur oxides and nitrogen oxides, Control of mobile source pollutants - Control of particulate matters – Techniques of air pollution control – equipment.					
				<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	analyze the nature and characteristics of air pollutants, and basic concepts of air quality management.	Analyzing (K4)												
CO2	identify, formulate and solve air pollution problems using air pollution control devices to meet applicable standards.	Applying (K3)												
CO3	apply the knowledge about particulate air pollutants and control devices.	Applying (K3)												
CO4	evaluate the air quality behaviour and its measurement.	Analyzing (K4)												
CO5	demonstrate air pollution control strategies in industries using various models.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Richard w. Boubetal, "Fundamentals of Air Pollution", Academic Press, New York, 1994. ISBN 0080507077														
2. Noel De Nevers, "Air Pollution Control Engineering", McGraw Hill, New York, 1995. ISBN-10: 0070393672														
3. M.N.Raoetal, "AirPollution" Tata McGraw Hill, 1989. ISBN-10 : 9780074518717														
<b>REFERENCES</b>														
1. David, H.F., Liu, Bela G., Liptak Air Pollution, Lweis Publishers, 2000.														
2. Stern, A.C., Air Pollution (Vol.I – Vol.VIII), Academic Press, 2006.														
3. Davis, W.T., Air Pollution Engineering Manual, John Wiley & Sons, Inc., 2000.														
4. Heck, R.M., and Farrauto, R.J., Catalytic Air Pollution Control: Commercial Technology, 2nd Edition John Wiley Sons, 2012														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	-	-	-	-	1	1	-	-	-	-	-	-
CO2	1	1	2	-	-	-	2	1	-	-	-	-	1	1
CO3	2	1	1	1	-	-	2	1	-	-	-	-	1	1
CO4	2	2	2	-	2	-	1	1	-	-	-	-	1	1
CO5	2	1	-	-	-	-	1	1	-	-	-	-	1	1



CM23252	WASTEWATER TREATMENT			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	gain knowledge on the waste water generation and the waste characteristic.						
2	learn the concepts of physio-chemical treatment methodologies.						
3	understand the concepts of biological treatment methodologies.						
4	impart knowledge on the theoretical knowledge and technology development of various wastewater treatment process.						
5	acquire knowledge on advanced technologies for treating wastewater.						
<b>UNIT I</b>	<b>WASTEWATER TREATMENT AN OVERVIEW</b>						<b>9</b>
Overall introduction about technologies adopted for water treatment, source and characteristics of waste water; regulations – health and environment concerns in waste water management.							
<b>UNIT II</b>	<b>PHYSICAL TREATMENT METHODS</b>						<b>9</b>
Activated sludge process and variations, sequencing batch reactors, membrane reactors-trickling filters-fluidized bed reactors, aerated lagoons, waste stabilization ponds- design of units – UASB, up flow filters.							
<b>UNIT III</b>	<b>CHEMICAL TREATMENT METHODS</b>						<b>9</b>
Role of unit processes in waste water treatment, principles of chemical treatment – coagulation, flocculation, precipitation, flotation, solidification and stabilization, disinfection.							
<b>UNIT IV</b>	<b>BIOLOGICAL TREATMENT METHODS</b>						<b>9</b>
Objectives of biological treatment, principles of aerobic and anaerobic treatment, kinetics of biological growth, factors affecting growth – attached and suspended growth, determination of kinetic coefficients for organics removal, biodegradability assessment, selection of bio reactors.							
<b>UNIT V</b>	<b>ADVANCED WASTEWATER TREATMENT</b>						<b>9</b>
Technologies used in advanced treatment- removal of colloids and suspended particles– TOC and heavy metal removal, membrane filtration – ion exchange – advanced oxidation process – zero liquid discharge.							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	compare the Physical and chemical Characteristics of wastewater and their measurement.					Applying (K3)	
CO2	evaluate the effluent treatment techniques through physical treatment methods.					Analyzing (K4)	
CO3	analyze the chemical reactions involved for effluent treatment.					Analyzing (K4)	

CO4	apply the concepts of biological treatment methods.	Applying (K3)
CO5	determine the suitable advanced techniques to completely eliminate the traces of toxicity.	Applying (K3)

**TEXT BOOKS**

1. G. Tchobanoglous, FI Biston, "Wastewater Engineering Treatment and Reuse", McGraw Hill, 2002. ISBN 0077441214
2. Industrial Waste Water Management Treatment and Disposal by Waste Water McGraw Hill III Edition 2008. ISBN 0071592393
3. S.P. Mahajan, "Pollution control in process industries", 27th Ed. Tata McGraw Hill Publishing Company Ltd., 2012. ISBN 0074517724

**REFERENCES**

1. Casey, T.J., Unit Treatment Processes in Water and Wastewater Engineering, John Wiley & Sons, 2006.
2. Metcalf & Eddy, Inc. Wastewater Engineering - Treatment, Disposal, and Reuse, Fourth Edition, Tata McGraw-Hill, 1995.
3. Cheremisinoff, P.N., Handbook of water and wastewater technologies, BH Publications, 2002.
4. Sincero, P.A., and Sincero, A.G., "Physical Chemical treatment of water and wastewater", IWA Publications, 2002.

**CO-PO MAPPING :**

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	-	-	-	-	1	1	-	-	-	-	1	-
CO2	1	1	2	-	-	-	3	1	-	-	-	-	1	1
CO3	2	1	1	1	-	-	2	1	-	-	-	-	-	1
CO4	1	2	1	-	2	-	1	1	-	-	-	-	1	1
CO5	2	1	1	-	-	-	1	1	-	-	-	-	-	1



CM23253	<b>SOLID WASTE MANAGEMENT</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the sources, types, and characteristics of municipal solid wastes and their impacts.						
2	learn methods for waste reduction, on-site storage, and recycling of various materials.						
3	understand techniques for the collection and transfer of residential and commercial wastes.						
4	know physical and thermal processing techniques for waste treatment and resource recovery.						
5	acquire knowledge on methods for the safe disposal of waste, including the design and management of sanitary landfills.						
<b>UNIT I</b>	<b>SOURCES AND CHARACTERISTICS</b>						<b>9</b>
Sources and types of municipal solid wastes- Public health and environmental impacts of improper disposal of solid wastes- sampling and characterization of wastes - factors affecting waste generation rate and characteristics - Elements of integrated solid waste management – Requirements and salient features of Solid waste management rules (2016) – Role of public and NGO"s- Public Private participation – Elements of Municipal Solid Waste Management Plan.							
<b>UNIT II</b>	<b>SOURCE REDUCTION, WASTE STORAGE AND RECYCLING</b>						<b>9</b>
Waste Management Hierarchy - Reduction, Reuse and Recycling - source reduction of waste – On-site storage methods – Effect of storage, materials used for containers – segregation of solid wastes – Public health and economic aspects of open storage – case studies under Indian conditions – Recycling of Plastics and Construction/Demolition wastes.							
<b>UNIT III</b>	<b>COLLECTION AND TRANSFER OF WASTES</b>						<b>9</b>
Methods of Residential and commercial waste collection – Collection vehicles – Manpower – Collection routes – Analysis of waste collection systems; Transfer stations –location, operation and maintenance; options under Indian conditions – Field problems- solving.							
<b>UNIT IV</b>	<b>PROCESSING OF WASTES</b>						<b>9</b>
Objectives of waste processing – Physical Processing techniques and Equipment; Resource recovery from solid waste composting and bio methanation; Thermal processing options – case studies under Indian conditions.							
<b>UNIT V</b>	<b>WASTE DISPOSAL</b>						<b>9</b>
Land disposal of solid waste- Sanitary landfills – site selection, design and operation of sanitary landfills – Landfill liners – Management of leachate and landfill gas- Landfill bioreactor – Dumpsite Rehabilitation - Incineration.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	explain solid waste characteristics and its sources.	Understanding (K2)												
CO2	identify and analyze different methods of treatment of solid waste.	Analyzing (K4)												
CO3	illustrate Industrial practices in solid waste management.	Applying (K3)												
CO4	explain the significance of recycling reuse and reclamation of solid wastes.	Understanding (K2)												
CO5	analyze the relationships between environmental guidelines, human activities and quality of impacted soil, water and air.	Analyzing (K4)												
<b>TEXT BOOKS</b>														
1. William A. Worrell, P. Aarne Vesilind (2012) Solid Waste Engineering, Cengage Learning, 2012. ISBN 1305888359														
2. John Pitchel (2014), Waste Management Practices-Municipal, Hazardous and industrial CRC Press, Taylor and Francis, New York. ISBN 1466585188														
3. Tchobanoglous, G., Theisen, H. M., and Eliassen, R. "Solid. Wastes: Engineering Principles and Management Issues". McGraw Hill, New York, 1993. ISBN 0070632375														
<b>REFERENCES</b>														
1. Government of India, "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, New Delhi, 2000.														
2. Manser A.G.R. and Keeling A.A "Practical handbook of processing and recycling municipal waste", Lewis Publishers, CRC Press, 1996.														
3. DhungelRajan, "Model of Solid Waste Management in urbanizing areas", LAP Lambert Academic Publishing 2014.														
4. Vesilind, P.A. and Rimer, A.E., "Unit Operations in Resource Recovery Engineering", Prentice Hall, Inc., 1981														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO3	2	1	1	1	-	-	2	1	-	-	-	-	1	1
CO4	2	2	2	-	2	-	1	1	-	-	-	-	-	1
CO5	2	1	2	1	-	-	2	1	-	-	-	-	1	-



CM23254	ENVIRONMENTAL IMPACT ASSESSMENT			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	acquire knowledge on EIA procedure in India						
2	understand identification and assessment of environmental impacts of a project						
3	gain knowledge on mitigation and management of impacts caused						
4	understanding on the importance and methods of performing social impacts of developmental projects						
5	learn monitoring methods and to develop knowledge of learning from EIA case studies						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Impacts of Development on Environment – Rio Principles of Sustainable Development-Environmental Impact Assessment (EIA) – Objectives – Historical development – EIA Types – EIA in project cycle – EIA Notification and Legal Framework.							
<b>UNIT II</b>	<b>ENVIRONMENTAL ASSESSMENT</b>						<b>9</b>
Screening and Scoping in EIA – Drafting of Terms of Reference, Baseline monitoring, Prediction and Assessment of Impact on land, water, air, noise, flora and fauna - Matrices – Networks – Checklist Methods - Mathematical models for Impact prediction.							
<b>UNIT III</b>	<b>ENVIRONMENTAL MANAGEMENT PLAN</b>						<b>9</b>
Plan for mitigation of adverse impact on water, air and land, water, energy, flora and fauna – Environmental Monitoring Plan – EIA Report Preparation – Public Hearing-Environmental Clearance.							
<b>UNIT IV</b>	<b>SOCIO ECONOMIC ASSESSMENT</b>						<b>9</b>
Baseline monitoring of Socio economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost benefit Analysis.							
<b>UNIT V</b>	<b>MONITORING STUDIES AND APPLICATION</b>						<b>9</b>
Environmental monitoring – guidelines, policies- planning of monitoring programmes, Environmental management Post project audit, case studies of EIA developmental projects in food, fertilizer and pharmaceuticals.							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	apply the concept of environmental Impact assessment					Analyzing (K4)	
CO2	compare various components and assessment techniques of EIA.					Applying (K3)	

CO3	evaluate Environmental management plan	Analyzing (K4)
CO4	analyze the socio economic impacts caused by the project	Analyzing (K4)
CO5	apply the knowledge through case studies and to study EIA monitoring	Applying (K3)

**TEXT BOOKS**

1. Canter, L. W., Environmental Impact Assessment, 2nd Edition, McGraw Hill, New York, 1996. ISBN: 9780070097674.
2. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, 2nd edition, Wiley, 2013. ISBN: 9781118678404.
3. Anjaneyulu, Y., and Manickam, V., Environmental Impact Assessment, Methodologies, 2nd Edition, CRC Press, 2011. ISBN:9780415665568

**REFERENCES**

1. Becker H. A., Frank Vanclay, “The International handbook of social impact assessment” conceptual and methodological advances, Edward Elgar Publishing, 2003. ISBN: 9781847201058
2. Barry Sadler and Mary McCabe, “Environmental Impact Assessment Training Resource Manual”, 2nd edition, United Nations Environment Programme, 2002. ISBN: 9280722301.
3. Judith Petts, “Handbook of Environmental Impact Assessment Vol. I”, Wiley-Blackwell Science, 1999. ISBN: 9780632047727
4. Ministry of Environment and Forests EIA Notification and Sectoral Guides, Government of India, Gazette of India, 2006.

**CO-PO MAPPING :**

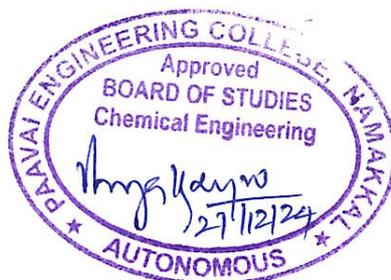
**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak**

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	1	-	1	-	-	1	1	-	-	-	-	1	1
CO2	2	1	-	1	-	1	1	1	-	-	-	-	2	2
CO3	1	1	-	1	-	1	2	1	-	-	-	-	1	1
CO4	1	2	-	1	-	1	2	1	-	-	-	-	1	1
CO5	1	1	-	1	-	-	3	1	-	-	-	-	-	-



CM23255	PRINCIPLES OF SAFETY MANAGEMENT			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	introduce the definitions, concepts, methodologies used in management of occupational safety in industries						
2	acquire knowledge on accident prevention methods in industries						
3	understand the importance of monitoring safety performance in industries						
4	recognize and evaluate occupational safety and health hazards in the workplace						
5	determine accident investigation and learn appropriate hazard controls following the hierarchy of controls.						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Safety-Goals of safety engineering. Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. History of safety movement. Theories of accident causation. Safety organization-objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.							
<b>UNIT II</b>	<b>ACCIDENT PREVENTION METHODS</b>						<b>9</b>
Importance, Various training methods, Effectiveness of training, Communication purpose, barrier to communication. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping so housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.							
<b>UNIT III</b>	<b>MONITORING SAFETY PERFORMANCE</b>						<b>9</b>
Frequency rate, severity rate, incidence rate, activity rate. Cost of accidents-Computation of Costs-Utility of Cost data. Plant safety inspection types, inspection procedure. Safety sampling techniques. Job safety analysis (JSA).							
<b>UNIT IV</b>	<b>SURVEYS AND AUDITS</b>						<b>9</b>
Safety surveys, Safety audits- documentation, interaction with people, questionnaires, etc.; use of audit checklists to conduct audits. Planning audits-Write inspection and audit reports. Safety Inventory Techniques.							
<b>UNIT V</b>	<b>ACCIDENT INVESTIGATION</b>						<b>9</b>
Accident investigation-purpose, timing, location, responsible and methodology; Basics-Man-Environment & Systems. Process of Investigation-Tools-Data Collection-Handling witnesses-Case study. Accident analysis-Analytical Techniques-System Safety-Change Analysis-MORT-Multi events Sequencing-TOR.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES															
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>													
CO1	illustrate the knowledge and understanding of basic terms in safety management.	Understanding (K2)													
CO2	discuss the safety organizational requirements for effective safety management.	Applying (K3)													
CO3	evaluate the workplace hazards and apply controls measures using hierarchy of control.	Analyzing (K4)													
CO4	evaluate the safety performance of an organization.	Analyzing (K4)													
CO5	assess the accident investigation methodologies and apply systematic procedure to identify unearh the root cause of the incident.	Applying (K3)													
<b>TEXT BOOKS</b>															
1. Roger, L.Brauer, "Safety and Health for Engineers" John Wiley & Sons, Inc.															
2. N.V.Krishnan, "Safety Management in Industry", Jaico Publishing House, 1997.															
<b>REFERENCES</b>															
1. Accident Prevention Manual for Industrial Operations:National Safety Council, Chicago.															
2. Willie Hammer, "Occupational Safety Management and Engineering", Prentice Hall.															
3. TedS.Ferry, "Modern Accident Investigation and Analysis", John Wiley and Sons															
4. John V. Grimaldi and Rollin H. Simonds, "Safety Management", All India Traveller Book Seller, Delhi.															
<b>CO-PO MAPPING :</b>															
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>															
<b>(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak</b>															
CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
CO1	2	2	1	1	2	1	1	-	1	-	-	1	2	3	
CO2	2	2	2	2	1	-	-	-	1	-	-	2	2	2	
CO3	2	2	1	2	2	-	-	1	1	1	-	2	2	3	
CO4	1	1	2	2	3	-	-	-	1	1	-	2	2	3	
CO5	2	2	1	1	1	-	-	-	-	-	1	2	2	1	



CM23256	RISK AND HAZOP ANALYSIS			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	acquire knowledge on risk, hazard and their assessment techniques in Industry						
2	know about the root cause analysis						
3	understand hazards in process and categorize zone level						
4	gain knowledge on risk assessment and eliminate hazard by engineering control.						
5	understand the importance of HAZOP in process industries						
<b>UNIT I</b>	<b>RISK ANALYSIS</b>						<b>9</b>
Risk analysis introduction, rapid risk analysis –comprehensive risk analysis – identification, evaluation and control of risk, Quantitative risk analysis, 5 why analysis, fish bone diagram, event tree, fault tree, consequence analysis and layer of protection analysis, Bow tie analysis.							
<b>UNIT II</b>	<b>RISK ASSESSMENT</b>						<b>9</b>
Risk assessment – introduction and available methodologies, quantitative risk assessment Risk assessment steps.							
<b>UNIT III</b>	<b>EMERGENCY PLANNING AND RESPONSE</b>						<b>9</b>
Overall risk analysis-emergency planning-on site and off site emergency planning, risk management ISO 14000, EMS models case studies- marketing terminal, gas processing complex ; Risk due to Radiation, explosion due to over pressure, jet fire-fire ball.							
<b>UNIT IV</b>	<b>HAZARDS</b>						<b>9</b>
Hazard -Types of Hazard, Hazard identification – methods: Process Hazard Analysis - Introduction to PHA, Overview of PHA Techniques, Selection of PHA techniques Implementation of recommendation – Key Aspects. Cyclic PHA /Revalidation; Review of PHA methodology (Prerequisites, Team Composition and their attributes).							
<b>UNIT V</b>	<b>HAZOP Analysis</b>						<b>9</b>
Introduction to HAZOP - Significance of HAZOP - HAZOP procedure – HAZOP Analysis - Computer usage in HAZOP- softwares employed - Limitations of HAZOP – case studies.							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	apply the knowledge of types of risks arising in working environment.					Applying (K3)	
CO2	evaluate risk assurance and assessment.					Analyzing (K4)	
CO3	design Risk management systems and planning.					Applying (K3)	

CO4	analyze the effect of process hazard.	Analyzing (K4)
CO5	compare Hazop and its consequences and to create hazard free working premises.	Applying (K3)

#### TEXT BOOKS

1. Daniel A. Crowl, J.F. Louvar, "Chemical Process Safety: Fundamentals with Applications", Prantice Hall, NJ, 1990. ISBN 0134857844, 9780134857848.
2. Fawatt, H.H. and Wood, W.S., "Safety and Accident Prevention in Chemical Operation", Wiley Inter science, 1965, ISBN 0470256788, 9780470256787.
3. Marcel, V.C., "Major Chemical Hazard", Ellis Harwood Ltd., Chi Chester, UK, 1987 ISBN 10085312969X.

#### REFERENCES

1. Handley, W., "Industrial Safety Hand Book ", 2nd Edition. McGraw-Hill Book Company, 1969.
2. Heinrich, H.W. Dan Peterson, P.E. and Rood, N., "Industrial Accident Prevention", McGraw-Hill Book Co., 1980.
3. Taylor, J.R., Risk analysis for process plant, pipelines and transport, Chapman and Hall, London, 1994.
4. Hyatt, N., Guidelines for process hazards analysis, hazards identification & risk analysis, Dyadem Press, 2004, ISBN9781315220376.

#### CO-PO MAPPING :

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	-	2	-	-	1	1	-	-	-	-	1	1
CO2	2	1	-	1	-	-	1	1	-	-	-	-	2	2
CO3	1	1	-	1	-	2	2	2	-	-	-	-	1	1
CO4	1	2	-	1	-	-	2	1	-	-	-	-	1	1
CO5	1	1	-	1	-	-	3	1	-	-	-	-	-	-



CM23257	<b>INDUSTRIAL SAFETY, HEALTH AND ENVIRONMENT ACTS</b>	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand health provisions related to hazardous processes as laid out in Factories act 1948				
2	learn about Environment act 1986 and rules framed under the act.				
3	acquire knowledge on major hazard control rules and amendment				
4	understand the acts of Indian boiler, mines and building construction				
5	analyze the international acts and standards.				
<b>UNIT I</b>	<b>FACTORIES ACT – 1948</b>				<b>9</b>
Statutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young persons – special provisions – penalties and procedures- Tamilnadu Factories Rules 1950 under Safety and health chapters of Factories Act 1948. Forms, Registers and notices – Tamilnadu Safety Officer Rules 2005- with updated Amendments.					
<b>UNIT II</b>	<b>ENVIRONMENT ACT – 1986</b>				<b>9</b>
General powers of the central government, prevention, control and abatement of environmental pollution-Biomedical waste (Management and handling Rules, 1989-The noise pollution (Regulation and control) Rules, 2000-The Batteries (Management and Handling Rules) 2001- No Objection certificate from statutory authorities like pollution control board. Water Act 1974: Central and state boards for the prevention and control of pollution-powers and functions of boards – prevention and control of air pollution and water pollution –fund – accounts and audit, penalties and procedures.					
<b>UNIT III</b>	<b>MAJOR ACCIDENT HAZARD CONTROL RULES AND AMENDMENT</b>				<b>9</b>
Definitions – duties of authorities – responsibilities of occupier – notification of major accidents – information to be furnished – preparation of offsite and onsite plans – list of hazardous and toxic chemicals – safety reports – safety data sheets. Major Accident Hazard Control Rules. Hazardous Wastes (management, handling and Trans boundary Movement) Rules 2016.					
<b>UNIT IV</b>	<b>OTHER ACTS AND RULES</b>				<b>9</b>
Indian Boiler (Amendments) Act 2007, static and mobile pressure vessel rules (SMPV), motor vehicle rules, The Mines and Minerals (Development & Regulation) Amendment Act, 2015, workman compensation act, rules – electricity act and rules – hazardous wastes (management, handling and trans boundary) rules, 2008 - the building and other construction workers act 1996., Petroleum rules, Gas cylinder rules 2016, Explosives Act 1884 - Pesticides Act – E waste (management) rules 2016.					
<b>UNIT V</b>	<b>INTERNATIONAL ACTS AND STANDARDS</b>				<b>9</b>
Occupational Safety and Health act of USA (The Williams - Steiger Act of 1970) – Health and safety work act (HASAWA 1974, UK) – ISO 14001 – ISO 45001 , European Safety and Health Legislations, American Petroleum Institute (API) Standards, Oil Industry Safety Directorate (OISD) Standards,					

National Fire Protection Association (NFPA) Standards, Atomic Energy Regulatory Board (AERB), American National Standards Institute (ANSI).															
												<b>TOTAL PERIODS</b>		45	
<b>COURSE OUTCOMES</b>															
At the end of this course, students will be able to												<b>BT Mapped (Highest Level)</b>			
CO1	recognize the important legislations related to health, Safety and Environment.											Applying (K3)			
CO2	discuss the requirements mentioned in factories act for the prevention of accidents.											Analyzing (K4)			
CO3	analyse the health and welfare provisions given in factories act.											Applying (K3)			
CO4	define the statutory requirements for an Industry on registration, license and its renewal.											Analyzing (K4)			
CO5	construct onsite and offsite emergency plan.											Applying (K3)			
<b>TEXT BOOKS</b>															
1. The Factories Act 1948, Madras Book Agency, Chennai, 2000.															
2. Indian Boilers Act and Regulations.															
<b>REFERENCES</b>															
1. The Factories Act 1948, Madras Book Agency, Chennai, 2000															
2. The Environment Act (Protection) 1986, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.															
3. Water (Prevention and control of pollution) act 1974, Commercial Law publishers (India) Pvt.Ltd.,New Delhi.															
4. Air (Prevention and control of pollution) act 1981, Commercial Law Publishers (India) Pvt.Ltd., New Delhi.															
<b>CO-PO MAPPING :</b>															
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<b>(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak</b>															
CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
CO1	1	2	-	2	-	-	1	1	-	-	-	-	1	1	
CO2	1	1	-	1	-	-	1	1	-	-	-	-	2	2	
CO3	1	1	-	1	-	2	2	2	-	-	-	-	1	1	
CO4	1	2	-	1	-	-	2	1	-	-	-	-	1	1	
CO5	1	1	-	1	-	-	2	1	-	-	-	-	-	-	



CM23351	BIOCHEMISTRY			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn the functions and structures of carbohydrates and lipids.						
2	know the fundamentals of proteins and amino acids.						
3	understand the catalytic activities of enzymes and factors affecting their functions.						
4	obtain knowledge on functions and structures of important vitamins.						
5	gain knowledge on digestion and absorption of various biomolecules.						
<b>UNIT I</b>	<b>CARBOHYDRATES AND LIPIDS</b>						<b>9</b>
Introduction to complex biomolecules, Carbohydrates: functions – classification, Monosaccharides: structural aspects – Reactions – derivatives, Disaccharides: maltose – sucrose – inversion of sucrose – lactose – sucralose, Polysaccharides, Homopolysaccharides, Heteropolysaccharides. Lipids: classification – functions – fatty acids – essential fatty acids – trans fatty acids – triacylglycerols – phospholipids.							
<b>UNIT II</b>	<b>AMINO ACIDS, PROTEINS AND NUCLEIC ACIDS</b>						<b>9</b>
Functions of proteins, Amino acids: general structure – classification – physical properties - chemical properties, Proteins: primary structure - secondary structure – tertiary structure – quaternary structure – properties – denaturation – classification – biological importance peptides. Nucleic acids: functions – nucleotides – structures of DNA and RNA.							
<b>UNIT III</b>	<b>ENZYMES</b>						<b>9</b>
Nomenclature and classification, chemical nature of enzymes, factors affecting enzyme activity, active site, enzyme inhibition, enzyme specificity, coenzymes, mechanism of enzyme action, regulation of enzyme activity in the living system, units of enzyme activity, non-protein enzymes, applications of enzymes, plasma enzymes, isoenzymes, enzyme pattern in diseases.							
<b>UNIT IV</b>	<b>VITAMINS</b>						<b>9</b>
History and nomenclature, classification of vitamins, Individual vitamins: structures and functions of Vitamin A, Vitamin D, Vitamin E, Vitamin K, Vitamin C, folic acid (Vitamin B9), cobalamin (Vitamin B12).							
<b>UNIT V</b>	<b>DIGESTION AND ABSORPTION</b>						<b>9</b>
Definition, gastrointestinal tract, Carbohydrates: digestion, absorption of monosaccharides, mechanism of absorption, Proteins: digestions, absorption of amino acids and dipeptides, mechanism of amino acid absorption, lipids: digestion, emulsification and absorption of lipids, mechanism of lipid absorption, nucleic acids, and abnormalities related to digestion and absorption.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	elucidate the functions and structures of carbohydrates and lipids.	Understanding (K2)
CO2	analyze biomolecules such as amino acids, proteins based on its properties and structures.	Analyzing (K4)
CO3	demonstrate the catalytic activities of enzymes and their importance in industries.	Understanding (K2)
CO4	enumerate classification and importance of vitamins.	Understanding (K2)
CO5	reveal the knowledge on digestion and absorption of various biomolecules.	Understanding (K2)

#### TEXT BOOKS

1. Satyanarayana, U. and Chakerapani,U., "Biochemistry" 6th Rev. Edition, Books & Allied Ltd., 2021.
2. Satyanarayana, U. and Chakerapani,U., "Essential of Biochemistry" 3rd Rev. Edition, Books & Allied Ltd., 2021.

#### REFERENCES

1. Lehninger Principles of Biochemistry 6th Edition by David L. Nelson, Michael M. Cox W.H. Freeman and Company, 2017.
2. Rastogi, S.C. "Biochemistry" 2nd Edition, Tata McGraw-Hill, 2003.
3. Conn, E.E., et al., "Outlines of Biochemistry" 5th Edition, John Wiley & Sons, 1987.
4. Voet, D. and Voet, J.G., "Biochemistry", 4th Edition, John Wiley & Sons Inc., 2010.

#### CO-PO MAPPING :

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	-	-	-	-	1	1	1	-	-	-	2	1	2
CO2	2	-	-	-	-	1	1	1	-	-	-	1	1	2
CO3	2	-	-	1	1	1	2	2	-	-	-	1	1	2
CO4	1	-	-	-	1	1	1	1	-	-	-	1	1	2
CO5	2	1	1	1	2	1	1	1	-	-	-	2	1	2



CM23352	<b>BIOCHEMICAL ENGINEERING</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the biochemical process and microbial structure.						
2	learn the immobilized enzyme technology and their kinetics						
3	acquire the knowledge on cellular growth structure and their kinetics.						
4	know the techniques in gas-liquid mass transfer in cellular systems and their power requirements.						
5	familiarize about the cell disruption, separation and purification methods.						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Industrial biochemical processes with typical examples, comparing chemical and biochemical processes, development and scope of biochemical engineering as a discipline. Industrially important microbial strains; their classification; structure; cellular genetics.							
<b>UNIT II</b>	<b>KINETICS OF ENZYME ACTION</b>						<b>9</b>
Kinetics of enzyme catalyzed reaction: the enzyme substrate complex and enzyme action - modulation and regulation of enzyme activity - types of inhibition. Immobilized enzyme technology: enzyme immobilization, Immobilized enzyme kinetics: effect of external mass transfer resistance.							
<b>UNIT III</b>	<b>KINETICS OF MICROBIAL GROWTH</b>						<b>9</b>
Kinetics of cellular growth in batch and continuous culture - models for cellular growth unstructured - structured and cybernetic models - medium formulation. Thermal death kinetics of cells and spores - stoichiometry of cell growth and product formation - Design and analysis of biological reactors.							
<b>UNIT IV</b>	<b>TRANSPORT PHENOMENA</b>						<b>9</b>
Transport phenomena in bioprocess systems: Gas-liquid mass transfer in cellular systems - determination of heat oxygen transfer rates, power requirements for sparged and agitated vessels - scaling of mass transfer equipment.							
<b>UNIT V</b>	<b>DOWN STREAM PROCESSING</b>						<b>9</b>
Downstream processing: Strategies to recover and purify products; separation of insoluble products - filtration and centrifugation; cell disruption-mechanical and non-mechanical methods; separation of soluble products: liquid-liquid extractions - membrane separation (dialysis, ultra filtration and reverse osmosis) - chromatographic Separation - gel permeation chromatography – electrophoresis - final steps in purification – crystallization and drying.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	explain the Basic biochemical engineering principles and applications relevant to bioprocesses.	Understanding (K2)												
CO2	choose the immobilized techniques and their substrates.	Applying (K3)												
CO3	design the suitable biological reactors and models for cellular growth.	Analyzing (K4)												
CO4	determine the power requirements for agitated vessels.	Analyzing (K4)												
CO5	sketch out the different steps in purification methods.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. J.E.Bailey and D.F.Ollis, "Biochemical engineering fundamentals" 2nd edition, , McGraw Hill, 1986.														
2. Michael L. Shuler and Fikret Kargi, "Bioprocess Engineering" 2nd edition, Pearson education.														
<b>REFERENCES</b>														
1. James M.Lee , "Biochemical Engineering" Prentice-Hall, 1992.														
2. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press.														
3. H.W. Blanch and D.S. Clark, Marcel Dekker, "Biochemical Engineering", 1997.														
4. Aiba, S; Humphrey, A.E., Milli, N.R., "Biochemical Engineering" 2nd ed., Academic Press, 1973.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	-	-	-	-	1	-	1	-	-	1	1	1	1
CO2	2	-	1	-	-	1	-	1	-	-	1	1	1	1
CO3	2	1	1	1	2	1	-	1	-	-	1	1	1	1
CO4	2	1	1	1	2	1	2	1	-	-	2	2	1	1
CO5	2	-	1	1	2	1	2	1	-	-	2	2	2	1



CM23353	<b>BIOPROCESS TECHNOLOGY</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn about the fundamental knowledge on bioprocess technology						
2	acquire knowledge on the various sterilization methods.						
3	know about the types of bioreactors.						
4	deduce the mass and heat transfer in biochemical process.						
5	understand on bio safety and bioethical issues.						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Biologists and Engineers, comparison of chemical and biochemical processing overview of biological basics, about cells and its growth, the stoichiometry of microbial growth and product. Bioprocesses: Regulatory Constraints.							
<b>UNIT II</b>	<b>STERILIZATION MEDIA</b>						<b>9</b>
Media formulation, Media Sterilization: Methods of heat sterilization of media, thermal death kinetics, design criteria, batch and continuous sterilization. Air Sterilization: Methods of air sterilization, mechanism of air sterilization, solid and liquid handling. Industrially fermented broth.							
<b>UNIT III</b>	<b>BIOREACTORS</b>						<b>9</b>
Purpose and importance of bioreactors, Classification of bioreactors, bioreactors for animal cells, bioreactors for plant cells, bioreactors for immobilized cells, operations of bioreactors, stirred tank reactor, plug flow reactor (PFR), fluidized bed reactor, bubble column, airlift reactor, Agitation, and Aeration: Mechanical agitation, power consumption in agitation, bubble aeration, bioreactors for waste management.							
<b>UNIT IV</b>	<b>TRANSPORT PROCESSES</b>						<b>9</b>
Aspects of rheology, Fluid flow in packed-bed and Fluidized bed columns, Gas-liquid mass transfer in cellular systems Diffusivity and mechanism of mass transfer - derivation of the equations of mass transport by diffusion-stationary and unsteady mass transport by diffusion, mass transfer coefficient, macroscopic balances for mass transport. Mechanisms and applications of heat transfer-mode of heat transfer-conduction, convection and radiation, Application of Heat and Mass transfer in biochemical processes.							
<b>UNIT V</b>	<b>BIOETHICS AND BIOSAFETY</b>						<b>9</b>
Introduction to Bioethics. Social and ethical issues, the process of biotechnology involved in generating new forms of life for informed decision making, Biosafety-definition; Biosafety for human health and environment. Social and ethical issues. Use of genetically modified organisms and their release into the environment.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	explain the biochemical processing, cells and microbial growth.	Understanding (K2)												
CO2	decide a right sterilization method for a medium.	Applying (K3)												
CO3	demonstrate the operations of bioreactors and their purpose	Applying (K3)												
CO4	elucidate the transportation processes in reactors and their behaviors	Understanding (K2)												
CO5	explicate the biosafety and information on bioethics.	Understanding (K2)												
<b>TEXT BOOKS</b>														
1. Bailey, J. E., and D. F. Ollis. Biochemical Engineering Fundamentals. 2nd ed. New York, McGraw-Hill, 1986.														
2. H. W. Blanch and D. S. Clark, Biochemical Engineering, Marcel, Dekker Inc., 1996.														
<b>REFERENCES</b>														
1. Bird R.B., Steward W.E., and Lightfoot E.N., Transport Phenomena, John Wiley & sons, Inc., New York, 2002														
2. C J Geankoplis, Transport Processes and Separation Processes Principles, 4th Edition, New Jersey, PHI Publishers, 2010														
3. Michael L. Shuler, Bioprocess Engineering: Basic Concepts, Pearson Education India; 2nd edition (1 January 2015),														
4. <a href="https://onlinecourses.nptel.ac.in/noc22_bt19-">https://onlinecourses.nptel.ac.in/noc22_bt19-</a> Bioreactor design and analysis														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	-	-	1	1	2	1	-	-	-	2	1	1
CO2	2	2	1	-	-	1	2	1	-	-	-	1	1	1
CO3	2	2	3	-	1	1	2	1	-	-	-	2	1	1
CO4	2	1	-	-	2	1	2	1	-	-	-	2	1	1
CO5	2	1	1	-	2	2	3	1	-	-	-	2	2	1



CM23354	<b>FERMENTATION TECHNOLOGY</b>	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	understand the overall industrial fermentation process and the process flow sheet.					
2	gain the knowledge on bacterial and algal biotechnology.					
3	understand the biological effluent treatment process					
4	learn knowledge on fermentation process economics					
5	acquire the knowledge for the production of modern biological products.					
<b>UNIT I</b>	<b>INTRODUCTION TO FERMENTATION</b>				<b>9</b>	
History and development of fermentation industry; General requirements of fermentation processes; types of fermentation – homo fermentation, hetero fermentation: category of fermentation based on end product formed – lactic acid fermentation, alcohol fermentation, acetic acid fermentation, butyric acid fermentation.						
<b>UNIT II</b>	<b>BACTERIAL AND ALGAL FERMENTATIONS</b>				<b>9</b>	
Isolation, preservation and improvement of industrially important micro- organisms. Microorganisms and raw materials used for microbial Oil production, Current technologies of biofuel production – Cyanobacterial and algal fuels; Fine chemicals and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology; Bioweapons and Bioshields.						
<b>UNIT III</b>	<b>BIOLOGICAL EFFLUENT TREATMENT</b>				<b>9</b>	
Microbes involved in aerobic and anaerobic processes in nature; Water treatment- BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal; secondary waste water treatment; use of membrane bioreactor; aquaculture effluent treatment; Aerobic sludge and land fill leachate process; aerobic digestion.						
<b>UNIT IV</b>	<b>FERMENTATION PROCESS ECONOMICS</b>				<b>9</b>	
Process economics: General fermentation process economics; materials usage and cost; capital investment estimate; production cost estimate. Case studies –Traditional product and recombinant product; Bioprocess validation: Introduction, why validation, when does validation occur, validation structure, resources for validation, validation of systems and processes including SIP and CIP.						
<b>UNIT V</b>	<b>FUTURE ASPECTS OF FERMENTATION ENGINEERING</b>				<b>9</b>	
Microbial fungicides and Pesticides, Chemicals and Pharmaceuticals made by fermentation, Fermented food products – Beer, Wine, Genetically Modified Organisms, Biopolymers. Microbial leaching, Effluent treatment using microbes, Future of fermentation technology and its products.						
					<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	explain the basics of industrial fermentation and other processes.	Understanding (K2)												
CO2	extend their knowledge on algal Biotechnology.	Applying (K3)												
CO3	extend their knowledge on the biological effluent treatment process.	Applying (K3)												
CO4	utilize their knowledge on importance of fermentation process economics	Applying (K3)												
CO5	apply their knowledge on commercial production of primary and secondary metabolites.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Peter F Stanbury, Allan Whitaker, Stephen J Hall. "Principles of Fermentation Technology", Butterworth-Heinemann Press. UK, 2016.														
2. H. J. Pepler, D. Perlman. "Microbial Technology: Fermentation Technology", Academic Press, 2014.														
<b>REFERENCES</b>														
1. T. El-Mansi, C. Bryce, Arnold L. Demain, A.R. Allman. Fermentation Microbiology and Biotechnology. Second Edition, CRC Press, USA, 2006.														
2. Pandey A, Lasroche C, Soccol C. R and Dussop C. G. "Advances in Fermentation technology", Asia tech publishers Inc., 2008.														
3. Peter,Max S. and Timmerhaus, Klaus D, "Plant Design and Economics for Chemical Engineers", McGraw Hill.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO2	2	2	1	-	-	2	1	1	-	-	-	1	1	1
CO3	2	2	-	1	1	3	1	1	-	-	-	2	1	1
CO4	1	1	1	1	2	1	2	1	-	-	-	2	1	1
CO5	1	1	-	1	-	1	1	1	-	-	-	1	2	1



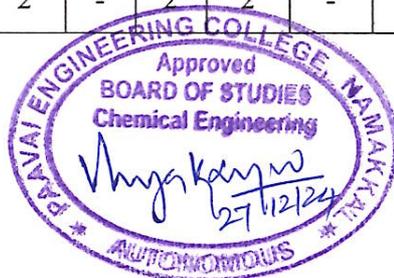
CM23355	<b>INDUSTRIAL BIOTECHNOLOGY</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn the basics of fermentation methodology						
2	obtain insight the production of primary metabolites						
3	understand the production of secondary metabolites						
4	acquire knowledge on the production of enzymes						
5	know about modern biotechnology products						
<b>UNIT I</b>	<b>BASICS OF FERMENTATIONS</b>						<b>9</b>
Fermentation - Bacterial, Fungal and Yeast, Biochemistry of fermentation. Traditional and Modern Biotechnology- A brief survey of organisms, processes, products. Basic concepts of Upstream and Downstream processing in Bioprocess, Process flow sheeting – block diagrams, pictorial representation.							
<b>UNIT II</b>	<b>PRODUCTION OF PRIMARY METABOLITES</b>						<b>9</b>
Primary Metabolites - Production of commercially important primary metabolites like organic acids, amino acids and alcohols.							
<b>UNIT III</b>	<b>PRODUCTION OF SECONDARY METABOLITES</b>						<b>9</b>
Secondary Metabolites - Production processes for various classes of secondary metabolites: Antibiotics, Vitamins and Steroids.							
<b>UNIT IV</b>	<b>PRODUCTION OF ENZYMES AND OTHER BIOPRODUCTS</b>						<b>9</b>
Production of Industrial Enzymes, Biopesticides, Biofertilizers, Bio preservatives, Biopolymers Biodiesel. Cheese, Beer, SCP & Mushroom culture, Bioremediation.							
<b>UNIT V</b>	<b>PRODUCTION OF MODERN BIOTECHNOLOGY PRODUCTS</b>						<b>9</b>
Production of recombinant proteins having therapeutic and diagnostic applications, vaccines. Bioprocess strategies in Plant Cell and Animal Cell culture.							
						<b>TOTAL PERIODS</b>	<b>45</b>
<b>COURSE OUTCOMES</b>							
At the end of this course, students will be able to						<b>BT Mapped (Highest Level)</b>	
CO1	utilize basic knowledge of fermentation and biotechnology in industries.					Understanding (K2)	
CO2	produce primary metabolites.					Applying (K3)	
CO3	generate secondary metabolites.					Applying (K3))	
CO4	work on enzymes and other bioproducts.					Applying (K3)	

CO5	oversee and report the production of modern biotechnology products.												Applying (K3)	
<b>TEXT BOOKS</b>														
1. Satyanarayana, U. "Biotechnology" Books & Allied (P) Ltd., 2005.														
2. Dubey, R.C. "A Textbook of Biotechnology" S.Chand & Co. Ltd., 2006.														
<b>REFERENCES</b>														
1. Prescott, S.C. and Cecil G. Dunn, "Industrial Microbiology", Agrobios (India), 2005.														
2. K.G.Ramawat & ShailyGoyal, "Comprehensive Biotechnology", S.Chand publications, 2009.														
3. Ratledge, Colin and Bjorn Kristiansen "Basic Biotechnology" 2 nd Edition Cambridge University Press, 2001.														
4. Balasubramanian, D., "Concepts in Biotechnology" Universities Press Pvt. Ltd., 2004.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO2	2	1	-	-	-	1	1	1	-	-	-	1	1	1
CO3	2	2	-	-	-	1	1	1	-	-	-	1	1	1
CO4	2	2	-	-	-	2	1	2	-	-	-	2	2	1
CO5	2	2	-	-	-	2	2	1	-	-	-	2	2	1



CM23356	DOWNSTREAM PROCESSING			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn about fundamental concepts of downstream processes.						
2	gain knowledge on the biological product separation.						
3	understand the biological product isolation.						
4	understand the methods to obtain pure biological product.						
5	acquire in depth knowledge on design and optimization of downstream process operations and equipment.						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Introduction to downstream processing - Principles - Characteristics of bio-molecules and bioprocesses, Cell disruption methods for product release; Mechanical, Enzymatic and Chemical methods; Pre-treatment and stabilization of bio-products.							
<b>UNIT II</b>	<b>PHYSICAL METHODS OF SEPARATION</b>						<b>9</b>
Cell disruption methods for intracellular products: Physical, chemical and mechanical - Removal of insoluble: Biomass and particulate debris separation techniques – flocculation – coagulation - sedimentation - centrifugation and filtration methods.							
<b>UNIT III</b>	<b>ISOLATION OF PRODUCTS</b>						<b>9</b>
Supercritical extraction - in situ product removal -Precipitation: Methods of precipitation with salts - organic solvents and polymers - Membrane based separations: Micro and ultra-filtration - theory - design and configuration of membrane separation equipments and its applications.							
<b>UNIT IV</b>	<b>PRODUCT PURIFICATION</b>						<b>9</b>
Reverse phase and hydrophobic interaction chromatography – Electrophoretic separation techniques: capillary - isoelectric focusing-2D gel electrophoresis - Hybrid separation technologies: GC-MS and LC-MS.							
<b>UNIT V</b>	<b>FINAL PRODUCT FINISHING OPERATIONS</b>						<b>9</b>
Crystallization: nucleation, crystal growth, crystal size distribution, kinetics of crystallization, population density, industrial crystallizers, recrystallization; drying - drying terminologies, drying curve, industrial dryers, freeze drying principles and applications. Biomolecules of Commercial importance Ethanol, citric acid.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	understand the physicochemical properties of biotechnological products and economics of downstream processing.	Understanding (K2)												
CO2	acquire knowledge about equipment selection and design of mechanical separation process for recovery of biotechnological products.	Understanding (K2)												
CO3	identify and optimize the suitable bioproduct isolation process at laboratory and pilot scale.	Applying (K3)												
CO4	understand the chromatographic separation technique and equipment selection during downstream processing.	Understanding (K2)												
CO5	understand the various techniques for stability of biotechnology products and will be capable of formulation and stabilization for the enhancement of shelf-life of the biotech products.	Understanding (K2)												
<b>TEXT BOOKS</b>														
1. Belter PA, Cussler E and Hu WS, "Bioseparation – Downstream Processing for Biotechnology", Wiley Interscience (1988).														
2. Asenjo, Juan A. "Separation Processes in Biotechnology". Taylor & Francis / CRC, 2000.														
<b>REFERENCES</b>														
1. R.O. Jenkins, (Ed.), "Product Recovery in Bioprocess Technology – Biotechnology" By Open Learning Series, Butterworth-Heinemann.														
2. J.C. Janson And L. Ryden, (Ed.), "Protein Purification – Principles, High Resolution Methods and Applications", VCH Pub. 2011.														
3. R.K. Scopes, "Protein Purification – Principles and Practice", Narosa Pub. 1994.														
4. Sivasankar, B. "Bioseparations : Principles and Techniques", PHI, 2005.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO2	2	2	-	2	3	-	1	2	1	-	-	2	2	2
CO3	2	2	-	2	3	-	2	2	1	1	-	2	2	2
CO4	2	1	-	2	3	-	2	2	1	1	-	2	2	2
CO5	2	2	-	1	2	-	2	2	-	-	1	2	2	2



CM23357	ENVIRONMENTAL BIOTECHNOLOGY	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	know the importance of biodegradation					
2	acquire knowledge on microbial decomposition of organic compounds.					
3	understand the aerobic and anaerobic treatment processes					
4	learn biotechnique principles for treating air pollutants					
5	know the technological methods to convert bio-waste into bio-products.					
<b>UNIT I</b>	<b>BIODEGRADATION</b>				<b>9</b>	
Aerobic degradation of aliphatic and aromatic compounds – Co-metabolic degradation of organo pollutants – Anaerobic degradation of aromatic compounds, halogenated organics and sulfonates – Biodegradation of herbicides and pesticides –Bio desulphurization of coal and oil – Bioleaching, bioprecipitation, bioaccumulation and biosorption of heavy metals.						
<b>UNIT II</b>	<b>MICROBIAL METABOLISM IN WASTEWATER TREATMENT</b>				<b>9</b>	
Decomposition of organic compounds in natural and manmade ecosystems – Mass and energy balance for aerobic and anaerobic reactions – Hydrolysis of biopolymers by aerobic and anaerobic microorganisms – Anaerobic degradation of carbohydrates, proteins, fats and lipids – Nitrogen removal – Ammonification, nitrification, denitrification, anaerobic ammonia oxidation – Enhanced biological phosphorus removal.						
<b>UNIT III</b>	<b>BIOLOGICAL TREATMENT OF WASTEWATER</b>				<b>9</b>	
Physico-chemical characteristics of wastewater – Overview of aerobic and anaerobic treatment processes – Process design of aerobic and anaerobic system – Activated sludge process – Trickling filter – Rotating biological contactors – Fluidized bed reactor – Upflow anaerobic sludge blanket reactor (UASB) – Membrane bioreactors – Algal photosynthesis in wastewater treatment.						
<b>UNIT IV</b>	<b>BIOTECHNOLOGY FOR AIR POLLUTION AND SOLID WASTE MANAGEMENT</b>				<b>9</b>	
Air pollution control and treatment strategies – Biotechnology for treating air pollutants – Biofilters and Bioscrubbers – Biotechnology for the management of agricultural, plastic, dairy, paper and pulp, textile, leather, hospital and pharmaceutical industrial wastes.						
<b>UNIT V</b>	<b>BIOPRODUCTS FROM RENEWABLE SOURCES</b>				<b>9</b>	
Overview of renewable sources – Production of biocompost and vermicompost – Production of biofertilizers and biopesticides – Production of biomethane, bioethanol, biohydrogen, biodiesel – Production of bioplastics and biopolymers – Bioelectricity generation and value added products from renewable sources.						
					<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES															
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>													
CO1	utilize the biodegradation techniques to reduce biomass.	Analyzing (K4)													
CO2	recognize the microbial processes for the treatment of wastewater	Applying (K3)													
CO3	develop the various biological processes for wastewater treatment	Analyzing (K4)													
CO4	integrate the biotechnology concepts for the control of air pollution	Understanding (K2)													
CO5	apply the knowledge for the development of bioproducts from renewable sources	Analyzing (K4)													
<b>TEXT BOOKS</b>															
1. Jordening, H.J. and Winter, J., "Environmental Biotechnology: Concepts and Application", Wiley-VCH Verlag GmbH & Co., 2005.															
2. Evans, G.G. and Furlong, J., Environmental Biotechnology: Theory and Application, 2nd Edition, John Wiley & Sons, 2011.															
<b>REFERENCES</b>															
1. Henze, M., Harremoes, P., Jansen, J.C. and Arvin, E., "Wastewater Treatment: Biological and Chemical Processes", 2nd Edition, Springer, 2013.															
2. Zarook, S. and Ajay,S., Biotechnology for Odor and Air Pollution Control, Springer, 2005.															
3. Wong J.W-C., Tyagi R.D., and Pandey. A., "Current Developments in Biotechnology and Bioengineering Solid waste" Elsevier, 2016.															
<b>CO-PO MAPPING :</b>															
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>															
<b>(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak</b>															
CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
CO1	2	2	1	1	2	1	1	-	1	-	-	1	2	2	
CO2	2	2	3	2	1	-	-	-	1	-	-	2	2	1	
CO3	3	2	2	2	2	-	-	1	1	1	-	2	2	2	
CO4	1	2	1	2	1	-	-	-	1	1	-	2	2	1	
CO5	2	2	2	1	1	-	-	-	-	-	1	2	2	2	



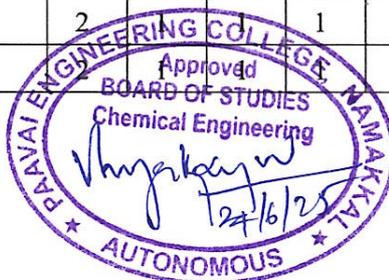
CM23451	BIOENERGY			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the sources, properties, and preparation methods of biomass for efficient energy utilization.						
2	relate the microbial processes, kinetics, and technologies involved in biogas production.						
3	summarize the principles and applications of pyrolysis and incineration in biomass conversion.						
4	interpret the thermochemical principles and design aspects of biomass gasification systems.						
5	express the principles of biomass combustion and evaluate cogeneration systems through industrial case studies.						
<b>UNIT I</b>	<b>INTRODUCTION TO BIOMASS</b>						<b>9</b>
Biomass sources and classification; Biomass characteristics and preparation; Chemical composition and properties of biomass; Size reduction, Briquetting of loose biomass, Drying, Storage and handling of biomass.							
<b>UNIT II</b>	<b>BIOGAS TECHNOLOGY</b>						<b>9</b>
Biogas technology: Feedstock for producing biogas; Microbial and biochemical aspects and operating parameters for biogas production, Kinetics and mechanism. Dry and wet fermentation, Digesters for rural application-High-rate digesters for industrial waste water treatment.							
<b>UNIT III</b>	<b>THERMOCHEMICAL CONVERSION</b>						<b>9</b>
Pyrolysis and thermo-chemical conversion: Thermo-chemical conversion of lignocellulosic biomass. Incineration for safe disposal of hazardous waste, Biomass processing for liquid fuel production, Pyrolysis of biomass-pyrolysis regime, effect of particle size, temperature, and products obtained.							
<b>UNIT IV</b>	<b>BIOMASS GASIFICATION</b>						<b>9</b>
Gasification of biomass: Thermochemical principles: Effect of pressure, temperature and introducing steam and oxygen. Design and operation of Fixed and Fluidized Bed Gasifiers, Safety aspects.							
<b>UNIT V</b>	<b>BIOMASS COMBUSTION AND COGENERATION SYSTEMS</b>						<b>9</b>
Combustion of biomass and cogeneration systems: Combustion of woody biomass-theory, calculations and design of equipment, Cogeneration in biomass processing industries. Case studies: Combustion of rice husk, Use of bagasse for cogeneration.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	describe and characterize various biomass sources and their properties.	Understanding (K2)												
CO2	explain the principles and processes involved in biogas production and evaluate different digester types.	Understanding (K2)												
CO3	describe the operations of thermochemical conversion technologies including incineration and pyrolysis.	Understanding (K2)												
CO4	analyze the thermochemical principles and operational parameters of biomass gasification.	Analyzing (K4)												
CO5	apply the concepts of biomass combustion and evaluate cogeneration systems through case studies.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Anju Dahiya, "Bioenergy: Biomass to Biofuels and Waste to Energy", Second Edition, Academic Press, Elsevier, 2020.														
2. Li, Yebo, and Samir Kumar Khanal, "Bioenergy: principles and applications", John Wiley & Sons, 2016.														
<b>REFERENCES</b>														
1. Vaughn C Nelson, Kenneth L. Starcher, "Introduction to bioenergy", CRC Press, 2017.														
2. Wall, Judy D., Caroline S. Harwood, and Arnold Demain. "Bioenergy", ASM Press, 2008.														
3. Bir Bahadur, Lakhveer Singh, and S.V. Ramanaiah, "Biomass and Bioenergy Solutions for Climate Change Mitigation and Sustainability", 1st Edition, Elsevier, Netherlands, 2022.														
4. Yebo Li and Samir Kumar Khanal, "Bioenergy: Principles and Applications", 1st Edition, Wiley-Blackwell, USA, 2016.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
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CO3	2	1	2	1		1	2	1	2		1	2	2	1
CO4	2	1	2	1	1	1	2		1	1	1	2	2	2
CO5	2	2	2	2	1	1	2		1	1	1	2	2	1



CM23452	<b>RENEWABLE ENERGY</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn the principles and applications of solar energy technologies.						
2	describe the solar thermal power plants.						
3	acquire knowledge of geothermal conversion systems.						
4	gain insight into wind energy production and utilization.						
5	comprehend the potential and technologies of tidal and ocean energy systems.						
<b>UNIT I</b>	<b>SOLAR ENERGY FUNDAMENTALS</b>						<b>9</b>
Introduction to renewable energy, Essential subsystems in a solar energy plant, Solar energy chains and their prospects, Basic approach and objectives, Phenomena of light and energy, Energy from the sun, Solar constant, Components of sun light and solar spectrum, beam radiation, diffuse radiation and global radiation, Power density for various wavelengths of sunlight, Clarity index, Seasonal variation, Solar insolation, Method of calculations.							
<b>UNIT II</b>	<b>SOLAR THERMAL POWER PLANTS</b>						<b>9</b>
Solar thermal collectors – modified flat plate, parabolic through, paraboloidal dish, Fresnel lense point focus, Heliostats with central receiver, Primary coolant, Thermal energy storage, Solar distributed collector and central receiver thermal power plant, Ratings of a solar energy plant, Solar boiler and steam generator with a large reflector and a central receiver, Solar Pond, Binary cycle solar thermal power plant.							
<b>UNIT III</b>	<b>GEO THERMAL ENERGY</b>						<b>9</b>
Utilization of geothermal energy, Geothermal gradients, Non-uniform Geothermal gradients, Hydro geothermal resources, Geo pressure geothermal resources, Hot dry rock geothermal resources, Geothermal fluids for electrical power plants, Classification and types of geothermal power plants – vapour dominated, liquid dominated, Hybrid conventional and geothermal power plants.							
<b>UNIT IV</b>	<b>WIND ENERGY</b>						<b>9</b>
Wind energy quantum, Variables in wind energy conversion systems, Wind power density, Power in a wind stream, Wind turbine efficiency, Forces on the blades of a propeller, Types of wind turbine- Horizontal and vertical axis, Wind to electric energy conversion systems, Power versus velocity characteristics of WTG units, Power duration curves.							
<b>UNIT V</b>	<b>OCEAN AND TIDAL ENERGY</b>						<b>9</b>
Ocean energy resources, Off-shore and on-shore ocean energy conversion technologies, Guidelines for ocean energy conversion plants, Ocean energy routes, Ocean waves, Parameters and equations of a progressive wave, Wave data collection, Routes of energy conversion of wave energy, Tidal currents, high and low rides, Tidal energy conversion, Tidal power, Tidal schemes – Single basin, Double basin,							

Multi basin.													<b>TOTAL PERIODS</b>		45
<b>COURSE OUTCOMES</b>															
At the end of this course, students will be able to												<b>BT Mapped (Highest Level)</b>			
CO1	describe the principles and working of solar energy.											Understanding (K2)			
CO2	apply the solar energy fundamentals to solar thermal power plants.											Applying (K3)			
CO3	explain the processes of geothermal power plants.											Understanding (K2)			
CO4	apply the wind energy concepts in wind to electrical energy conversion systems.											Applying (K3)			
CO5	compare and interpret various ocean energy technologies for practical use.											Understanding (K2)			
<b>TEXT BOOKS</b>															
1. Mukherjee, D., and S. Chakrabarti, "Fundamentals of renewable energy systems", New Age International, 2004.															
2. Rao S. and Dr. B.B. Parulekar, "Energy Technology", 3 <sup>rd</sup> Edition, 14 <sup>th</sup> reprint, Khanna Publishers, 2017.															
<b>REFERENCES</b>															
1. Kishore, V. V. N., ed. "Renewable energy engineering and technology: principles and practice", The Energy and Resources Institute (TERI), 2010.															
2. Tiwari, Gopal Nath, and Rajeev Kumar Mishra, "Advanced renewable energy sources", Royal Society of Chemistry, 2012.															
3. Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.															
4. Sukhatme S. P., Nayak J. K., Solar Energy: Principles of thermal Collection and Storage, 3 <sup>rd</sup> Ed., Tata McGraw-Hill Education Pvt. Ltd 2008.															
<b>CO-PO MAPPING :</b>															
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak															
CO's	PO's												PSO's		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	
CO1	1	1	1	1		2	1	2			1	2	2	2	
CO2	1	1	2	2		2	1	2	1	1	1	2	2	2	
CO3	1	2	2	2		2	1	1	1	1	1	2	2	2	
CO4	1	2	2	2		2			1	1	1	2	1	1	
CO5	1	2	2	2						1	1	2	2	2	



CM23453	<b>ENERGY TECHNOLOGY</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn about different types of energy sources and global/national energy usage trends.						
2	explain how to calculate and convert different forms of energy.						
3	know the basics of energy management and its importance in saving energy and money.						
4	describe India's energy policies and future planning in energy sectors.						
5	suggest ways to reduce energy use in industries learn how to perform energy audits.						
<b>Unit - I</b>	<b>INTRODUCTION TO ENERGY</b>						<b>9</b>
Energy - Energy Technology and Energy Sciences, Energy, Man and Environment, Law of conservation of Energy, Energy chains, Energy routes, Energy resources and forms of energy, Energy demand, Energy consumption trends, Energy supply network, National energy strategies and national energy plan, Cost comparison of energy resources and conversion, Energy conservation opportunities.							
<b>Unit - II</b>	<b>ENERGY CALCULATIONS</b>						<b>9</b>
Measurement and units, Dimensional equations, Additions of energy, Energy conversion equations, Mechanical energy, work and power, Kinetic energy, Mechanical to electrical energy conversion, Electrical to thermal conversion, Active power and reactive power, Importance of power factor, kVA rating and kW power, Chemical energy, Energy values.							
<b>Unit - III</b>	<b>ENERGY MANAGEMENT</b>						<b>9</b>
Two sides of energy management, Sectors and hierarchical levels of supply side energy management, objectives of energy management, Trade-off between energy and environment, Energy and economy, Infrastructure planning, transportation of energy, per capita energy consumption, Energy management and control systems for demand side, Seven principles of energy management.							
<b>Unit - IV</b>	<b>ENERGY POLICY AND PLANNING</b>						<b>9</b>
Energy strategy, policy and planning, Energy policy of a supply organization and demand side organization, National energy strategies of India, Electric power sector planning in India, India's Non-conventional, renewable and alternative energy planning, Energy consumption trends in India, integrated estimates, Energy conservation measures under 9 <sup>th</sup> five year plan,							
<b>Unit - V</b>	<b>ENERGY CONSERVATION AND AUDIT</b>						<b>9</b>
Energy conservation opportunities (ECO), Energy conservation measures (ECM), Listing of energy conservation opportunities, ECOs in chemical process industry, Types of energy audits – walk through, intermediate, comprehensive, End use energy consumption profile, procedure of energy auditing, composition of comprehensive audit team, data for comprehensive audit, site testing and measurement.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	describe the types, forms, and routes of energy along with national and global consumption trends and conservation opportunities.	Understanding (K2)												
CO2	apply appropriate energy conversion equations and perform energy-related calculations across various physical and chemical systems	Applying (K3)												
CO3	explain energy management principles, levels of implementation, and their interrelation with environment and economy.	Understanding (K2)												
CO4	analyze the key components of energy policy and planning, especially with reference to Indian national strategies and sectoral planning.	Analyzing (K4)												
CO5	conduct energy audits in industrial setups and recommend energy conservation opportunities in line with current auditing practices	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Rao S. and Dr. B.B. Parulekar, "Energy Technology", 3 <sup>rd</sup> Edition, 14 <sup>th</sup> reprint, Khanna Publishers, 2017.														
2. Twidell John and Weir Tony, "Renewable Energy Sources", 2 <sup>nd</sup> Edition, Taylor and Francis, New York, 2006.														
<b>REFERENCES</b>														
1. Beggs Clive, "Energy: Management Supply and Conservation", Butterworth-Heinemann, Oxford, 2002.														
2. Fay James A and Golomb Dan S, "Energy and the Environment", Oxford University Press Inc., New York, 2002.														
3. S. A. Abbasi and Nasema Abbasi, "Renewable Energy Sources and Their Environmental Impact", 1st Edition, PHI Learning Pvt. Ltd., India, 2022.														
4. Godfrey Boyle, "Renewable Energy: Power for a Sustainable Future", 4 <sup>th</sup> Edition, Oxford University Press, United Kingdom, 2016.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	2	-	3	3	1	-	-	-	2	2	2
CO2	2	2	2	2	-	3	3	-	-	-	-	2	2	2
CO3	2	2	2	2	-	3	3	-	2	2	2	2	2	2
CO4	2	2	2	2	-	3	3	-	3	2	2	2	2	2
CO5	2	2	2	2	-	3	3	-	3	3	3	2	2	2



CM23454	<b>ELECTROCHEMICAL ENGINEERING</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the basic principles and laws of electrochemistry and electrochemical kinetics.						
2	learn the role of transport phenomena and electrode configurations in electrochemical systems.						
3	outline the components, operation, and performance characteristics of batteries and fuel cells.						
4	comprehend the structure, operation, and evaluation of electrochemical energy storage systems.						
5	infer the design principles and industrial applications of electrochemical reactors.						
<b>UNIT I</b>	<b>BASICS OF ELECTROCHEMICAL ENGINEERING</b>						<b>9</b>
Importance of electrochemical systems: Faraday's law - Current density - Potential and Ohm's law. Cell potential. Electrochemical kinetics: Double layer - Butler-Volmer Kinetic Expression - Influence of Mass Transfer on the Reaction Rate - Current efficiency.							
<b>UNIT II</b>	<b>ELECTRON MOBILITY AND ELECTRODE INTERFACES</b>						<b>9</b>
Mobility of electrons in cells, Concentration over potential, Current distribution and membrane transport. Electrode configuration – Porous electrodes, characterization, current distribution, three phase electrodes, Electrodes with flow.							
<b>UNIT III</b>	<b>BATTERIES AND FUEL CELLS</b>						<b>9</b>
Components of a cell - Classification of batteries and cell - Theoretical capacity and state of charge - Cell characteristics and electrochemical performance - Heat efficiency of secondary cells- Charge retention and self-discharge - capacity fade in secondary cells. Fuel cell fundamentals: Types of fuel cells- Current-voltage characteristics and polarizations - Electrode structure - Proton-Exchange Membrane (PEM) fuel cells - Solid Oxide Fuel cells.							
<b>UNIT IV</b>	<b>ELECTROCHEMICAL ENERGY STORAGE SYSTEMS</b>						<b>9</b>
Introduction to energy storage principles in electrochemical systems. Overview of battery components, types (Li-ion, Pb-acid, Na-S), and performance metrics. Concepts of charge, discharge, efficiency, cycle life, and thermal management. Basics of supercapacitors and comparison with conventional batteries.							
<b>UNIT V</b>	<b>ELECTROCHEMICAL REACTOR DESIGN AND APPLICATIONS</b>						<b>9</b>
Classification and design of electrochemical reactors: batch, flow-by, flow-through types. Concepts of current distribution, mass transfer, limiting current, and over potential. Design considerations for packed-bed and high-surface-area electrodes. Applications in electro-synthesis, metal recovery, and wastewater treatment.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	explain the electrochemical principles, including Faraday's laws, cell potential, and kinetics.	Understanding (K2)												
CO2	apply transport and electrode concepts for optimizing electrochemical system performance.	Applying (K3)												
CO3	infer battery, fuel cell systems, their structure, capacity, and performance.	Understanding (K2)												
CO4	analyze the working, characteristics, and limitations of electrochemical energy storage systems like batteries and supercapacitors.	Analyzing (K4)												
CO5	apply design principles to electrochemical reactors and evaluate their role in industrial and environmental applications.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Thomas F.Fuller and John N.Harb, "Electrochemical Engineering", 1st Edition, John Wiley & Sons, USA, 2018.														
2. John Newman and Karen E. Thomas-Alyea, "Electrochemical Systems", 3rd Edition, John Wiley & Sons, USA, 2004.														
<b>REFERENCES</b>														
1. Allen J Bard and Larry R. Faulkner, "Electrochemical Methods, Fundamentals and Applications", 2nd Edition, John Wiley & Sons Inc, United State of America, 2000.														
2. Fumio Hine, "Electrochemical Engineering", 1 <sup>st</sup> Edition, Springer, Japan, 1985.														
3. Carl H. Hamann, Andrew Hamnett, and Wolf Vielstich, "Electrochemistry", 2 <sup>nd</sup> Edition, Wiley-VCH, Germany, 2007.														
4. Alexander V. Lvov (Editor), "Introduction to Electrochemical Science and Engineering", 2nd Edition, Routledge, United Kingdom, 2024.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	1									2	2	2
CO2	3	2	1		2		1					2	2	1
CO3	3	2	1		1		2				2	2	2	2
CO4	3	2	1	1	2	1	2	1	1	1	2	2	2	1
CO5	3	2	1	1	1		1		1	1	2	2	2	2



CM23455	HYDROGEN AND FUEL CELL TECHNOLOGY			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	provide a comprehensive overview of fuel cell technology, types, performance, modeling, and system integration.						
2	introduce the thermodynamic principles relevant to fuel cells including energy balances and voltage prediction.						
3	study the kinetics of electrochemical reactions in fuel cells and related transport phenomena.						
4	explore hydrogen production methods and integration with fuel cell systems.						
5	describe the hydrogen storage, infrastructure, safety, and policy for fuel cell system integration.						
<b>UNIT I</b>	<b>INTRODUCTION TO FUEL CELLS</b>						<b>9</b>
Introduction: Types of fuel cells, advantages and disadvantages of fuel cells; working and operation of fuel cell, fuel cell efficiency, Performance of fuel cell, Characterization and modelling of fuel cells - in-situ and ex-situ characterization techniques, i-V curve, frequency response analysis; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models.							
<b>UNIT II</b>	<b>FUEL CELL THERMODYNAMICS</b>						<b>9</b>
Introduction to Thermodynamics, Heat Potential of a Fuel: Enthalpy of Reaction, Work Potential of a Fuel: Gibbs Free Energy, Predicting Reversible Voltage of Fuel cell under non-standard-state conditions, Thermal and Mass Balances in fuel cells, Thermodynamics of Reversible fuel cells.							
<b>UNIT III</b>	<b>FUEL CELL REACTION KINETICS</b>						<b>9</b>
Electrode kinetics – Electrode reactions, overpotential types, Tafel equation, exchange current density; Charge transfer mechanisms – Charge transfer resistance, electrochemical activation, electro catalysis and catalyst design; Mass transport phenomena – Reactant/product transport in electrodes, diffusion and convection in porous media, electrolyte conductivity; Flow field design – Flow channel configurations, gas diffusion layer behavior, optimization for uniform distribution and performance;							
<b>UNIT IV</b>	<b>PRODUCTION OF HYDROGEN</b>						<b>9</b>
Hydrogen economy – Role in sustainable energy systems, global energy trends, relevance to decarbonization; Hydrogen production methods – Electrolysis, steam methane reforming, partial oxidation, biological and thermochemical methods; Hydrogen storage – Compressed gas, liquefied hydrogen, metal hydrides, chemical storage materials; System integration and analysis – Balance of plant (BoP), safety protocols, cost considerations, lifecycle integration with fuel cells.							
<b>UNIT V</b>	<b>HYDROGEN UTILIZATION, STORAGE, AND INFRASTRUCTURE</b>						<b>9</b>
Hydrogen properties and handling – Physical and chemical properties, flammability, leakage detection, odorization techniques, Hydrogen storage technologies – Compressed gas, liquefied hydrogen, cryo-compressed storage, metal							

hydrides, chemical hydrogen carriers, Hydrogen distribution and infrastructure – Pipelines, tube trailers, refueling stations, hydrogen purity requirements, on-site generation.

**TOTAL PERIODS**

**45**

**COURSE OUTCOMES**

At the end of this course, students will be able to

**BT Mapped  
(Highest Level)**

CO1	understand the fundamentals, types, performance, and system modeling of fuel cells.	Understanding (K2)
CO2	apply thermodynamic principles to evaluate fuel cell energy balances and reversible voltages.	Applying (K3)
CO3	analyze fuel cell electrode kinetics, charge transfer, and mass transport phenomena.	Analysing (K4)
CO4	identify and evaluate hydrogen production methods, safety, and cost for fuel cell integration	Understanding (K2)
CO5	explain hydrogen utilization, safety standards, and supporting policy frameworks.	Understanding (K2)

**TEXT BOOKS**

1. Gregor Hoogers, "Fuel Cell Technology Handbook", CRC Press, 2003.
2. R.P. O'Hayre, S. Cha, W. Colella, F.B. Prinz, "Fuel Cell Fundamentals", Wiley, 2006.

**REFERENCES**

1. S. Basu, "Fuel Cell Science and Technology", Springer, 2007.
2. H. Liu, "Principles of Fuel Cells", Taylor & Francis, 2006.
3. A. J. Bard, L. R. Faulkner, "Electrochemical Methods", Wiley, 2004.
4. Yashan Xing, Modeling and Control Strategies for a Fuel Cell System, Springer, 2024

**CO-PO MAPPING:**

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	1	1			2	2		1	1	1	2	2	2
CO2	2	2	2	3	1	2	2		1	2	1	2	2	2
CO3	2	2	2	3	3	2	2		1	2	1	2	2	2
CO4	2	2	2	3	3	2	2		1	2	2	2	2	2
CO5	2	2	2	3	3	2	2		1	1	1	2	2	2



<b>CM23456</b>	<b>NON - RENEWABLE ENERGY SOURCES</b>			<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the origin, composition, extraction, refining processes, and environmental issues related to petroleum and its products.						
2	study the types, composition, analysis, processing methods of coal and its applications in power generation, including environmental impacts.						
3	explore the resources, properties, transportation, and industrial applications of natural gas along with associated environmental concerns.						
4	learn the nuclear reaction principles, fuel processing, reactor types, and safety measures.						
5	explore unconventional fossil fuels like oil shale, tar sands, and gas hydrates and their exploitation challenges.						
<b>UNIT I</b>	<b>PETROLEUM</b>						<b>9</b>
Introduction, Origin of Petroleum, Composition, Extraction of Petroleum, Oil Recovery, Details of Unit Process, Products of Petroleum refining – Asphalt, Diesel, Gasoline, Liquefied Petroleum Gas (LPG), kerosene, Fuel oil, Tar, Lubricant, Paraffin, and Bitumen. Petrochemicals. Environmental Issues associated with petroleum resources.							
<b>UNIT II</b>	<b>NATURAL GAS</b>						<b>9</b>
Sources of Natural Gas, Properties and classification of natural gas, products from natural gas, transportation of natural gas, liquefied natural gas, chemicals from natural gas-Hydrogen cyanide, chloromethane, acetylene, carbon black, carbon disulfide, methanol, Fischer - Tropsch Synthesis shale gas; Liquefied Natural Gas (LNG), Environmental Issues associated with usage of Natural Gas.							
<b>UNIT III</b>	<b>COAL</b>						<b>9</b>
Types of coal- Peat, Lignite, Subbituminous, Bituminous, Anthracites. Composition of coal: Oxygen content, Proximate and Ultimate Analysis of coal; Carbonization, Coal for generation of electricity, coal liquefaction, coal blending, Calorific value and its determination, Coal burning - Environmental Issues associated with usage of coal.							
<b>UNIT IV</b>	<b>NUCLEAR ENERGY AND REACTOR TECHNOLOGY</b>						<b>9</b>
Nuclear models, binding energy, radioactivity, half-life, isotopes, isobars, and isotones, Nuclear fission and fusion: mechanisms, chain reaction, conditions for fusion, temperature and confinement, Uranium enrichment, nuclear fuels – characteristics, production, and purification, Types of nuclear reactors: boiling water reactors (BWR), pressurized heavy water reactor (PHWR), fast breeder reactor (FBR), basics of fusion reactors, Nuclear power plant operation, safety measures, and radioactive waste management.							
<b>UNIT V</b>	<b>UNCONVENTIONAL FOSSIL RESOURCES</b>						<b>9</b>
Oil shale and tar sands – origin, composition, extraction techniques (surface mining, in-situ methods), and upgrading processes, Gas hydrates – structure, occurrence in marine and permafrost regions, methods of extraction, potential as future energy source, Comparison with conventional fossil fuels – energy yield,							

processing challenges, and environmental impacts, Technological advancements and economic feasibility of commercial exploitation.

**TOTAL PERIODS**      45

**COURSE OUTCOMES**

At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>
CO1	explain the origin, extraction, and refining of petroleum and its products.	Understanding (L2)
CO2	analyze different types of coal and their applications in energy generation.	Analyzing (L4)
CO3	explain the properties, classification, and applications of natural gas.	Understanding (L2)
CO4	explain nuclear energy fundamentals, reactor operations, and waste management practices.	Understanding (L2)
CO5	describe extraction methods, evaluate environmental impacts, and understand policy aspects of unconventional resources.	Understanding (L2)

**TEXT BOOKS**

1. Viswanathan, Balasubramanian, "Energy sources: fundamentals of chemical conversion processes and applications" Newnes, 2016.
2. Rao, S., and B. B. Parulekar. "Energy Technology: Non-conventional, Renewable and Conventional", 3<sup>rd</sup> edition, Khanna Publication, 2012.

**REFERENCES**

1. Breeze, Paul. "Nuclear power", Academic Press, 2016.
2. T.K. Ghosh & M. A. Prelas, Energy Resources and Systems: Volume 1 – Fundamentals and Non-Renewable Resources, Springer, 2009.
3. Benjamin K. Sovacool, "Contesting the Future of Nuclear Power: A Critical Global Assessment of Atomic Energy", World Scientific, 2011.
4. Alice Friedemann, "Life after Fossil Fuels: A Reality Check on Alternative Energy Sources", Springer, 2021.

**CO-PO MAPPING:**

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
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CO1	2	2	2	2	-	-	-	-	1	-	1	1	1	1
CO2	2	2	2	2	-	-	-	-	1	-	1	1	1	1
CO3	2	2	2	2	-	-	-	-	1	-	1	1	1	1
CO4	2	2	2	2	-	-	-	-	1	-	1	1	1	1
CO5	2	2	2	2	-	-	-	-	1	2	3	1	1	1



CM23457	POWER PLANT ENGINEERING			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the classification, planning, and thermodynamic cycles used in various types of power plants.						
2	study the types, construction, and applications of boilers used in steam generation and industrial heating systems.						
3	learn the working principles, classifications, and performance aspects of steam turbines and their role in power conversion.						
4	explore the components, types, and efficiency of gas turbine systems along with associated troubleshooting techniques.						
5	understand environmental impacts of power plants and explore methods for controlling emissions and pollution.						
<b>UNIT I</b>	<b>FUNDAMENTALS AND THERMODYNAMIC CYCLES OF POWER PLANTS</b>						<b>9</b>
Introduction – concept of power plants, classification of power plants: energy, resources for power generation power generation, future planning for power generations. Classification of power plant cycle – Carnot cycle, Rankine cycle, Reheat cycle, Regenerative cycles. Steam generators and condensers.							
<b>UNIT II</b>	<b>STEAM BOILERS AND HEAT GENERATION SYSTEM</b>						<b>9</b>
Boiler classification – based on pressure, fuel used, application, circulation method, and construction; Types of boilers – Overview of fire tube and water tube boilers with examples like Lancashire, Cochran, and Babcock Wilcox; Advanced boilers – Fluidized Bed Boilers (FBC), Positive Circulation Boilers for high-pressure applications, features and advantages; Special-purpose boilers – Thermal liquid heaters and vaporizers used in indirect heating systems, working principle and industrial applications							
<b>UNIT III</b>	<b>STEAM TURBINES AND POWER CONVERSION MECHANISMS</b>						<b>9</b>
Principle and operations of Steam Turbines: Classification of steam turbine, simple & compound impulse turbine, reaction turbine; capacity of steam turbine, choice of steam turbine: steam turbine generators and its specifications, Troubleshooting and Remedies							
<b>UNIT IV</b>	<b>GAS TURBINE SYSTEMS AND AUXILIARY COMPONENTS</b>						<b>9</b>
Introduction to Gas Turbines: Classification and comparison of different types gas turbine power plants components open cycle and closed cycle gas turbine power plant, Elements of gas turbine power plants – Compressors, Intercoolers and Heat Exchangers, Combustion chambers, Gas turbine efficiency, Troubleshooting and remedies.							
<b>UNIT V</b>	<b>POLLUTION AND ENVIRONMENTAL MANAGEMENT IN POWER PLANT ENGINEERING</b>						<b>9</b>
Introduction, Environment Pollution due to Energy Use, Industrial Emissions, Harmful Effects of Emissions, Pollution – Air Pollution, Noise Pollution, Water Pollution, Green House Gases and their Effects, Fossil Fuel Pollution, impacts & methods for pollution control.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	explain the types of power plants and thermodynamic cycles along with steam generators and condensers.	Understanding (L2)
CO2	identify different types of boilers and explain their construction, operation, and applications in power generation.	Understanding (L2)
CO3	classify various steam turbines, their specifications and functions.	Analysing (L4)
CO4	compare open and closed cycle gas turbines and their performance.	Understanding (L2)
CO5	analyze pollution issues, pollution control and environmental management strategies.	Analysing (L4)

#### TEXT BOOKS

1. Elliott, Thomas C., Chen, Kao, and Swanekamp, Robert, "Standard Handbook of Power plant engineering", McGraw-Hill, 1997.
2. P. K. Nag, McGraw-Hill Education, latest Indian edition (McGraw-Hill e-text availability 2025)

#### REFERENCES

1. E L Wakil, "Power Plant Engineering", McGraw-Hill Book Co, N.Y. 2001
2. Arora and Domkundwar, "A course in Power Plant Engineering", Dhanpat Ra, N. Delhi.2003
3. Nag, P.K., "Power Plant Engineering", 2<sup>nd</sup> Edition, TMH, 2001
4. James Taylor, "Handbook of Power Plant Engineering", Oxford Book Company, 1 January 2024.

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CO1	2	1	1			2	2		1	1	1	1	2	2
CO2	2	2	2	2		2	2		1	1	2	1	2	2
CO3	2	2	2	2		2	2		1	1	1	1	2	2
CO4	2	2	2	2		2	2		2	1	-	1	2	2
CO5	2	2	2	2	2	2	2		2	1	1	1	2	2



CM23551	<b>PROCESS MODELING AND SIMULATION</b>	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	introduce the role and mathematical of models in chemical process systems.					
2	teach the applicability of dynamic behavior of lumped parameter systems in chemical processes					
3	expose the students to modelling principles involving complex phenomena.					
4	teach the applicability of distributed parameter models for processes involving spatial variations.					
5	equip the students with simulation tools to tackle engineering problems.					
<b>UNIT I</b>	<b>INTRODUCTION TO PROCESS MODELING AND SIMULATION</b>	<b>9</b>				
Uses of Mathematical Models - Scope of Coverage - Principles of Formulation; Fundamental Laws - Continuity Equation – Energy equation - Equations of motion - Transport equations - Equations of State - Equilibrium - Chemical Kinetics Problems.						
<b>UNIT II</b>	<b>MATHEMATICAL MODELS OF CHEMICAL ENGINEERING SYSTEMS</b>	<b>9</b>				
Introduction - Series of Isothermal, Constant-Holdup CSTRs - CSTRs With Variable Holdups - Two Heated Tanks - Gas-Phase, Pressurized CSTR – Non-isothermal CSTR - Single-Component Vaporizer - Multicomponent Flash Drum - Batch Reactor.						
<b>UNIT III</b>	<b>STAGED OPERATIONS AND DISTRIBUTED SYSTEMS</b>	<b>9</b>				
Reactor With Mass Transfer - Ideal Binary Distillation Column - Multicomponent Non-ideal Distillation Column - Batch Distillation with Holdup - pH Systems - Equilibrium-Constant Models, Titration-Curve Method.						
<b>UNIT IV</b>	<b>COMPUTER SIMULATION</b>	<b>9</b>				
Numerical Methods - Introduction - Computer Programming - Iterative Convergence Methods - Interval Halving, Newton-Raphson Method, False Position, Explicit Convergence Methods, Wegstein, Muller Methods - Numerical Integration of Ordinary Differential Equations - Explicit Numerical Integration Algorithms, Implicit Methods.						
<b>UNIT V</b>	<b>SIMULATION OF BASIC MODELS</b>	<b>9</b>				
Simulation Examples - Gravity-Flow Tank - Three CSTR's in Series - Non-isothermal CSTR - Binary Distillation Column - Multicomponent Distillation Column - Variable Pressure Distillation - Approximation Variable - Pressure Model, Rigorous Variable-Pressure Model - Batch Reactor - Ternary Batch Distillation with Holdup Problems.						
					<b>TOTAL PERIODS</b>	<b>45</b>



COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	understand the fundamentals of modeling and their applications to transport/energy equations, chemical and phase equilibria kinetics	Understanding (K2)												
CO2	analyze the principles of steady state/unsteady state lumped systems and steady state/ unsteady state distributed systems	Analyzing (K4)												
CO3	create the mathematical models for different unit operations equipment's	Applying (K3)												
CO4	associate the model with constitutive relations such as Newton-Raphson Method, Wegstein, Muller Methods, and Implicit Methods Problems.	Analyzing (K4)												
CO5	apply relevant solution methods for the mathematical models with relevant initial and/or boundary condition	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Luyben, W.L, "Process Modeling, Simulation and Control for Chemical Engineers", McGraw Hill, International Student Edition, Second Edition, 1996.														
2. Babu, B V., "Process Plant Simulation", Oxford University Press, 2004														
<b>REFERENCES</b>														
1. Bequette, B. W., "Process Dynamics: Modeling, Analysis, and Simulation", Prentice-Hall, 2002.														
2. Ramirez, W. D., "Computational Methods for Process Simulation", Second Edition, Elsevier Science, 1997.														
3. Jana, A. K., "Chemical Process Modeling and Computer Simulation", Second Edition, Prentice Hall India Pvt. Ltd, 2011.														
4. Klaus M. Hantos and István T. Cameron "Process Modelling and Model Analysis" Second Edition, Academic Press, 2001														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
<b>(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak</b>														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	2	1	1	1				1	1	2	2
CO2	2	2	2	2	2	1	1				1	1	2	2
CO3	2	2	2	2	2	1	1				1	1	2	2
CO4	2	2	2	2	2	1	1				1	1	2	2
CO5	2	2	2	2	2	1	1				1	1	2	2



CM23552	OPTIMIZATION OF CHEMICAL PROCESSES	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	impart knowledge on optimization techniques in chemical engineering processes				
2	enable students to understand the concepts of optimization				
3	obtain a mathematical representation of the Linear optimization problem				
4	obtain a mathematical representation of the Non-linear optimization problem				
5	emphasis on problems arising in Chemical Engineering applications				
<b>UNIT I</b>	<b>PROBLEM FORMULATION &amp; CLASSIFICATION</b>				<b>9</b>
Introduction – Scope and Hierarchy of optimization – Examples of Application of Optimization – The Essential Features of Optimization Problem - General Procedure for Solving Optimization Problems – Developing Models for Optimization – Classification of Models, How to Build a Model – Formulation of the Objective Function – Economic Objective Functions, Measures of Profitability.					
<b>UNIT II</b>	<b>BASIC CONCEPTS OF OPTIMIZATION</b>				<b>9</b>
Continuity of Functions – NLP Problem Statement – Convexity and its Applications – Interpretation of the Objective Function in Terms of its Quadratic Approximation – Optimization of Unconstrained Functions: One-Dimensional Search – Newton and Quasi-Newton Methods of Uni-dimensional Search – Polynomial Approximation Methods.					
<b>UNIT III</b>	<b>LINEAR PROGRAMMING</b>				<b>9</b>
Geometry of Linear Programs – Basic Linear Programming Definitions and Results – Simplex Methods – Barrier Methods – Sensitivity Analysis – Linear Mixed Integer Programs - LP Software.					
<b>UNIT IV</b>	<b>NON-LINEAR PROGRAMMING</b>				<b>9</b>
Direct Substitution - Quadratic Programming – Penalty, Barrier, and Augmented Lagrangian Methods – Successive Linear Programming – Successive Quadratic Programming - Relative Advantages and Disadvantages of NLP Methods.					
<b>UNIT V</b>	<b>APPLICATIONS OF OPTIMIZATION</b>				<b>9</b>
Heat transfer and energy conservation – Optimizing Recovery of Waste Heat, Optimal Shell and Tube Heat Exchanger Design - Separation Processes – Optimal Design and Operation of a Conventional Staged-Distillation Column, Optimization of Flow Rates in a Liquid-Liquid Extraction Column - Chemical Reactor Design and Operation – Optimal Design of an Ammonia Reactor.					
<b>TOTAL PERIODS</b>					<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	identify the basic problem formulation and optimization.	Applying (K3)
CO2	access various techniques used in constrained optimization	Analyzing (K4)
CO3	evaluate mathematical characteristics of Linear programming	Applying (K3)
CO4	demonstrate computational solution techniques for nonlinear unconstrained optimization.	Applying (K3)
CO5	apply the optimal and dynamic optimization.	Applying (K3)

#### TEXT BOOKS

1. Edgar T.F., Himmelblau D.M., Lasdon,L.S., "Optimization of Chemical Processes", Second Edition, McGraw-Hill, New York, 2001.
2. Rao, S. S., "Engineering Optimization: Theory and Practice", Fifth Edition, Wiley, New York, 2019.

#### REFERENCES

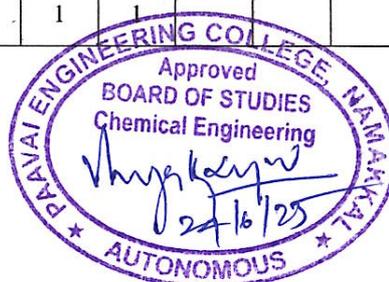
1. Reklaitis G.V., Ravindran A., Ragsdell, K.M., "Engineering Optimization", Wiley, New York, 1980.
2. A. Ravindran, K. M. Ragsdell, G. V. Reklaitis, "Engineering Optimization: Methods and Applications", 2nd Edition, Wiley India, 2006.
3. Ramirez, W. "Computational Methods in Process Simulation", 2nd Edn., Butterworths Publishers, New York, 2000
4. J K Sharma, "Operation Research Theory and application", 6<sup>th</sup> edition, Trinity, 2016

#### CO-PO MAPPING :

#### Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	2	2	2	1	1				1	2	2	2
CO2	1	2	2	2	2	1	1				2	2	2	2
CO3	1	2	2	2	2	1	1				2	2	2	2
CO4	2	2	2	2	2	1	1				2	2	2	2
CO5	2	2	2	2	2	1	1				2	2	2	2



CM23553	<b>CHEMICAL PROCESS FLOW SHEETING</b>	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	understand the basic concept of preparation of flow sheet.					
2	impart knowledge on flow sheet preparation by advanced process simulation.					
3	understand how to invent chemical process flow sheets					
4	generate and develop process flow sheet operations					
5	know the uses of flow sheeting in Chemical Engineering applications					
<b>UNIT I</b>	<b>INTRODUCTION TO FLOWSHEETING</b>	<b>9</b>				
Introduction – Flow sheet Presentation – Block Diagram, Presentation of Stream Flow Rates, Layout, Precision of Data, Batch Processes, Utilities, Equipment Identification, Computer-Aided Drafting – Process Simulation Programs – Specification of Components and Physical Property Models – Simulation of Unit Operations– Reactors, Other Separations, Heat Exchange, Hydraulics.						
<b>UNIT II</b>	<b>ADVANCED PROCESS SIMULATION AND OPTIMIZATION</b>	<b>9</b>				
User Models – Spreadsheet Models, User Subroutines – Flow sheet with Recycle – Tearing the Flow sheet, Convergence Methods, Manual Calculations, and Convergence Problems – Flow sheet Optimization – Use of Controllers, Optimization Using Process Simulation Software - Dynamic Simulation.						
<b>UNIT III</b>	<b>DEVELOPMENT OF FLOWSHEETING</b>	<b>9</b>				
General Procedure – Process Information –Molecular Path Synthesis, selecting Process Pathway, Production Mode, Recording Decisions – Input/output Structure – Functions Diagram – Preprocessing, Reactions, Recycle, By-products, Intermediates, and wastes, Separations.						
<b>UNIT IV</b>	<b>FLOWSHEET OPERATIONS DIAGRAM</b>	<b>9</b>				
Operation Diagrams – Preprocessing, Reactors, Separations Methods, Heating and Cooling, Minimization of Processing – Process Flow sheet – Reactors, Mass and Energy Balances, Separation Trains, Heat Exchange – Algorithmic Flow sheet Generations, Fundamentals of Algorithmic Process-Network Synthesis, and Application of Algorithmic Process-Network Synthesis.						
<b>UNIT V</b>	<b>APPLICATIONS OF FLOWSHEETING</b>	<b>9</b>				
Applications to Staged Operations –Applications to a Management Problem – Simulation of Flows in Pipe Networks – Application to Distillation - Application to Multiple Reaction Equilibrium.						
					<b>TOTAL PERIODS</b>	<b>45</b>



COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	infer the basic concept in preparation of flowsheet	Understanding (K2)
CO2	explain the flowsheet preparation by equation solving methods	Applying (K3)
CO3	evaluate different approach in flow sheeting	Analyzing (K3)
CO4	demonstrate the knowledge on preparing networks	Applying (K3)
CO5	evaluate the application using flow sheeting software.	Analyzing (K3)

**TEXT BOOKS**

1. Babu, B V., Process Plant Simulation, Oxford University Press, 2004
2. A.W.Westerberg., HP Hutchison., process flow sheeting., Cambridge university press., 2011  
ISBN- 10 : 0521279151

**REFERENCES**

1. Bequette, B.W., "Process Dynamics: Modelling, Analysis and Simulation," Prentice Hall, 1998.
2. Luyben, W.L., "Process Modelling Simulation and Control", 2nd Edn, McGraw-Hill Book
3. Douglas, J. M., Conceptual Design of Chemical Process, McGraw Hill, 1988. ISBN-10 : 0070177627
4. Marlin, Thomas E., "Process Control: Designing Processes and Control Systems for Dynamic Performance", 2nd Edition McGraw-Hill, 2000.

**CO-PO MAPPING :**

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
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CO1	2	2	2	2	2	1	1				1	2	2	2
CO2	2	2	2	2	2	1	1				1	2	2	2
CO3	2	2	2	2	2	1	1				2	2	2	2
CO4	2	2	2	2	2	1	1				2	2	2	2
CO5	2	2	2	2	2	1	1				2	2	2	2



CM23554	COMPUTATIONAL FLUID DYNAMICS	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	understand the basic concepts of CFD					
2	know the basics in momentum equation and energy equation					
3	equip the students to use finite volume methods for computational studies					
4	impart knowledge on computational solution techniques					
5	enable the students to evaluate flow field computation techniques for mesh generation					
<b>UNIT I</b>	<b>GOVERNING EQUATIONS</b>				<b>9</b>	
Introduction – Models of Flow – The Continuity Equation – Model of the Finite Control Volume Fixed in Space, Model of the Finite Control Volume Moving with the Fluid - The Momentum Equation – The Energy Equation–Equations for Viscous Flow - Equations for Inviscid Flow.						
<b>UNIT II</b>	<b>BASIC COMPUTATIONAL TECHNIQUES</b>				<b>9</b>	
Discretisation – Converting Derivatives to Discrete Expressions –Spatial Discretisation – Discretisation Methods – The Finite Difference Method – The Finite Element Method – The Finite Volume Method – Temporal Discretisation – The Accuracy of the Discretisation Process.						
<b>UNIT III</b>	<b>MODELLING AND FINITE VOLUME METHOD</b>				<b>9</b>	
Effect of turbulence in time-averaged Navier-Stokes equation, Characteristics of Turbulent flows - Turbulence models, mixing length model, The k-omega models, Reynolds stress equation model, and algebraic stress equation model. The diffusion equation – The Convection Diffusion Equation – The Upwind Scheme –Extension to multi-dimensionality problems – Unstructured grids.						
<b>UNIT IV</b>	<b>SOLUTION METHODS SYSTEMS OF EQUATIONS</b>				<b>9</b>	
Nonlinear Systems – Newton’s Method – Quasi-Newton Method – Methods for the solution of linear systems – Iterative methods – Basic iterative methods – Conjugate gradient methods – Multigrid acceleration.						
<b>UNIT V</b>	<b>MESH GENERATION</b>				<b>9</b>	
Structured grids – Boundary-fitted meshes –Algebraic grid generation – Partial Differential equation mesh generation – Unstructured grids – Surface meshing – Advancing front method – Delaunay triangulation						
					<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	apply the basics of CFD and governing equations for conservation of mass momentum and energy	Applying (K3)
CO2	demonstrate knowledge in various discretization techniques used in CFD	Applying (K3)
CO3	compare computational solution techniques for time integration of ordinary differential equations	Applying (K3)
CO4	analyze mathematical characteristics of partial differential equations	Analyzing (K4)
CO5	evaluate flow field computation techniques for mesh generation	Applying (K3)

#### TEXT BOOKS

1. Versteeg H. K. and Malalasekera, W., "An introduction to computational fluid dynamics: the finite volume method", Second edition, Pearson, 2008.
2. Anderson, J. D. "Computational fluid dynamics: The Basics with Applications", McGraw-Hill, 1995.

#### REFERENCES

1. Ranade, V. V., "Computational flow modeling for Chemical Reactor Engineering", Academic Press, 2002.
2. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2001.
3. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Pearson Education, 2nd Edition, 2007.
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., "Computational Fluid Mechanics and Heat Transfer", Taylor & Francis, 2nd Edition, 1997.

#### CO-PO MAPPING :

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	2	2	2	2	1				1	2	2	2
CO2	2	2	2	2	2	2	1				1	2	2	2
CO3	2	2	2	2	2	2	1				1	2	2	2
CO4	2	2	2	2	2	2	1				1	2	2	2
CO5	2	2	2	2	2	2					1	2	2	2



CM23555	<b>PINCH ANALYSIS AND HEAT EXCHANGER NETWORK DESIGN</b>	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the pinch concept and methods of pinch analysis				
2	identify minimum energy targets				
3	summarize different choices and constraint during heat exchange networking.				
4	interpret the knowledge of heat and power systems				
5	know the case studies for pinch analysis and network design				
<b>UNIT I</b>	<b>INTRODUCTION TO PINCH ANALYSIS</b>				<b>9</b>
Pinch Analysis -Process Synthesis -Heat recovery and heat exchange – The pinch and its significance – Heat exchanger network design –Choosing $\Delta T_{\min}$ : super targeting– Methodology of pinch analysis.					
<b>UNIT II</b>	<b>DATA EXTRACTION AND ENERGY TARGETING</b>				<b>9</b>
Data extraction – Heat and mass balance, Stream data extraction, Calculating heat loads and heat capacities, Choosing streams, Mixing, Heat losses – Energy targeting - $\Delta T_{\min}$ contributions for individual streams, Threshold problems –Targeting for organics distillation plant case study – Energy targeting, Area targeting, Cost targeting, Zonal targeting, Targeting with utility streams included.					
<b>UNIT III</b>	<b>HEAT EXCHANGER NETWORK DESIGN</b>				<b>9</b>
Introduction – Heat exchange equipment – Stream splitting and cyclic matching – Network relaxation – More complex design – Multiple pinches and near-pinches – Retrofit design.					
<b>UNIT IV</b>	<b>UTILITIES, HEAT AND POWER SYSTEMS</b>				<b>9</b>
Types of heat and power systems – Basic principles of heat engines and heat pumps – Appropriate placement for heat engines and heat pumps – CHP Systems – Practical heat engines, Selection of a CHP system, Organic Rankine cycles – Heat pumps and refrigeration systems – Heat pump cycles, Refrigeration systems, Shaft work analysis, Cooling water systems.					
<b>UNIT V</b>	<b>CASE STUDIES</b>				<b>9</b>
Crude preheat train – Pinch identification and network design – Aromatics plant – Design of an MER network, Network design based on existing layout –Evaporator/dryer plant –Stream data extraction, Heat pumping strategy - Organic chemicals manufacturing site – Process description and targeting, Practical implementation.					
<b>TOTAL PERIODS</b>					<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	analyze the pinch concept and process thermodynamics.	Analyzing (K4)
CO2	perform various types of energy targets	Applying (K3)
CO3	apply strategies for retrofitting existing process plant, integration of energy demands in multiple processes.	Applying (K3)
CO4	understand the concept of process thermodynamics	Understanding (K2)
CO5	evaluate the case studies for pinch analysis	Applying (K3)

#### TEXT BOOKS

1. Smith, R., Chemical Process: Design and Integration, 2nd Edition, Wiley, 2016.
2. Shenoy, V. U., Heat Exchanger network synthesis, Gulf Publishing, 1995.

#### REFERENCES

1. Douglas, J. M., Conceptual Design of Chemical Process, McGraw Hill, 1988
2. Kemp, I. C., Pinch Analysis and Process Integration, Second edition, Elsevier, 2006.
3. Linnhoff, B., User Guide on Process Integration for the Efficient Use of Energy, Institution of Chemical Engineers (IChemE), 1994.
4. El-Halwagi, M.M., Process Integration, Academic Press, 2006.

#### CO-PO MAPPING :

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and  
Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO2	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO3	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO4	3	3	3	-	-	-	-	-	-	-	-	-	3	3
CO5	3	3	3	-	-	-	-	-	-	-	-	-	3	3



CM23556	<b>MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING</b>	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the fundamentals and applications of AI in chemical engineering.				
2	learn the principles and operations of Deep Artificial Neural Networks (DNN).				
3	explore Convolutional Neural Networks (CNN) and their role in pattern recognition.				
4	study notable deep networks and the concept of Transfer Learning.				
5	examine sequence modelling using Recurrent Neural Networks (RNN) and their variants.				
<b>UNIT I</b>	<b>INTRODUCTION TO ARTIFICIAL INTELLIGENCE IN CHEMICAL ENGINEERING</b>				<b>9</b>
Introduction to Artificial Intelligence; Applications of AI in chemical engineering areas like Process control, Process design, Planning and operations, Modelling and simulation and Product design, development and selection like Separation Design, Heat-Exchanger Network Synthesis, Thermodynamic Model Selection and Physical Property Estimation.					
<b>UNIT II</b>	<b>DEEP ARTIFICIAL NEURAL NETWORKS (DNN)</b>				<b>9</b>
Activation functions and their importance in incorporating nonlinearities into the predictive models. The feed forward process in ANN layers with dense fully connected layers. The error (loss) functions as a measure of the ANN performance. Back propagation algorithm for neuron learning. Various optimization algorithms for neuron learning like Adams, Stochastic Gradient, Descent and their variations.					
<b>UNIT III</b>	<b>CONVOLUTION NEURAL NETWORKS (CNN).</b>				<b>9</b>
The drawbacks of Deep ANN. How CNN take into account the spatial patterns. The working of the CNN in pattern recognition. The role of kernels, pooling, padding and stride in CNN learning. How the kernels help in reducing the learning parameters (weight sharing). One-, two- and three-dimensional convolutions. The problems of vanishing/exploding gradients in deep networks.					
<b>UNIT IV</b>	<b>ADVANCED DEEP NETWORKS AND TRANSFER LEARNING</b>				<b>9</b>
Some outstanding deep networks proposed like Alex Net, VGG Net, Inception, Google Net and Res Nets. The problems they faced and how they resolved the problems. The concept of Transfer Learning and how one can use these proposed networks to solve other relevant problems. Auto encoders for dimensionality reduction.					
<b>UNIT V</b>	<b>SEQUENCE MODELING USING THE RECURRENT NEURAL NETWORKS (RNN)</b>				<b>9</b>
The application of this architecture in predictions based on sequential data. Various RNN architectures proposed like many to one, One to many and many to many. The variants of RNN like Gated Recurrent Units					



(GRU) and the Long Short-Term Memory (LSTM) architectures. Object Detection with the R-CNN, Fast and Faster R-CNN algorithms.															
												<b>TOTAL PERIODS</b>		<b>45</b>	
<b>COURSE OUTCOMES</b>															
At the end of this course, students will be able to												<b>BT Mapped (Highest Level)</b>			
CO1	understand Artificial Intelligence (AI) techniques in chemical engineering for processes											Understanding (K2)			
CO2	develop deep artificial neural networks (DNN) by implementing optimization algorithms.											Applying (K3)			
CO3	examine convolutional neural networks (CNN) to address vanishing gradient issues.											Analyzing (K4)			
CO4	analyze advanced deep networks such as AlexNet, VGGNet, Inception, and ResNets.											Analyzing (K4)			
CO5	apply recurrent neural networks (RNN) predictions based on sequential data, object detection using R-CNN algorithms.											Applying (K3)			
<b>TEXT BOOKS</b>															
1. S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach", 3 <sup>rd</sup> Edition, Mc Grew Hill, Prentice Hall 2009.															
2. Thomas Quantrille Y.Liu, "Artificial Intelligence in Chemical Engineering", 1 <sup>st</sup> Edition 1992															
<b>REFERENCES</b>															
1. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", 1 <sup>st</sup> Edition, Mc Graw Hill, 2008															
2. Deepak Khemani, "A First Course in Artificial Intelligence", 1 <sup>st</sup> Edition, Tata McGraw Hill Education, 2013															
3. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3 <sup>rd</sup> Edition, Pearson Education, 2010.															
4. Elaine Rich, Kevin Knight, and Shivashankar B. Nair, "Artificial Intelligence", 3 <sup>rd</sup> Edition, Tata McGraw Hill, 2009.															
<b>CO-PO MAPPING :</b>															
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>															
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak															
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CO2	3	3	2	2	3	3	1	-	-	-	2	2	3	2	
CO3	3	3	2	2	3	3	1	-	-	-	2	2	3	2	
CO4	3	3	3	2	3	3	1	-	-	-	2	2	3	2	
CO5	3	3	2	2	3	3	1	-	-	-	2	2	3	2	



CM23557	COMPUTER APPLICATIONS IN CHEMICAL ENGINEERING	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	obtain skills in basic principle and laws using in computer application					
2	solve mathematical models through numerical methods and Programming language					
3	understand the concept of Heat transfer and fluid flow operations					
4	know the fundamental database concepts, including MATLAB, Aspen and Aspen Plus					
5	understand the fundamental concepts and principles of mathematical programming					
<b>UNIT I</b>	<b>INTRODUCTION OF COMPUTER APPLICATION IN CHEMICAL ENGINEERING</b>				<b>9</b>	
The Two Building blocks of Chemical Engineering: Unit Operation and Unit Process – Chemical Process industry – Chemical Plant – Process Design – Design variables for sizing piping and process equipment – Basic Laws – Mass and Energy Conversion: Material, Balance and Heat Balance – Gas laws						
<b>UNIT II</b>	<b>NUMERICAL METHODS</b>				<b>9</b>	
Introduction – Basic definitions and Introductory – Algorithms – Programming Language – Areas and Domain of Numerical methods – Applications using elementary numerical method –The approach to solve problem by computer – Methodology – Model Development and Mathematical formulation – Applications						
<b>UNIT III</b>	<b>FLUID FLOW AND HEAT TRANSMISSION</b>				<b>9</b>	
Definition and terminology in fluid mechanics – classification of fluid flow – Parameters in laminar flow – fluid statics – Heat transmission – Modes of heat transfer – Heat transfer by conduction – Heat transfer by convection – Heat transfer by radiation – Heat Exchangers						
<b>UNIT IV</b>	<b>EQUATION OF STATE</b>				<b>9</b>	
Equations of state using mathematical formulation – Solving equation of state using Excel - Solving equation of state using MATLAB – Equation of state with Aspen – Thermodynamic Parameter – Nonideal Liquids – Test of thermodynamic model – NIST Thermo Data Engine in Aspen Plus						
<b>UNIT V</b>	<b>MATHEMATICAL PROGRAMMING</b>				<b>9</b>	
Mathematical Formulation of Reactor problems – Using MATLAB to solve ordinary differential equations – Using Comsol Multiphysics to solve ordinary differential equations – plug flow chemical reactors in Aspen Plus – Continuous Stirred Tank Reactors						
					<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	understand the principles and laws for Computer applications	Understanding (K2)												
CO2	perform mathematical models through numerical methods and Programming language	Applying (K3)												
CO3	know the concept of fluid flow operation and Heat Transfer in computer applications	Understanding (K2)												
CO4	design database with data models using MATLAB, Aspen and Aspen Plus	Analyzing (K4)												
CO5	apply the fundamental principles of mathematical programming	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Hanna, O.T. Scandell, O.C., "Computational Methods in Chemical Engineering", 1 <sup>st</sup> Edition, Prentice Hall, 1995														
2. R.K. Taxali, T.K.Base, "IV made simple, 1 <sup>st</sup> Edition, Tata McGraw-Hill, 1991.														
<b>REFERENCES</b>														
1. Jerry, O., Breneman, G.L., "Spreadsheet Chemistry", 1 <sup>st</sup> edition, Prentice Hall, 1991														
2. Myers, A.L. Seider W.D., "Introduction to Chemical engineering and Computer Calculation", 3 <sup>rd</sup> Edition, Prentice Hall, 1998														
3. Finlayson, B.A., "Introduction to Chemical Engineering Computing", 2nd Edition, Wiley, 2012.														
4. Rice, R.G., and Do, D.D., "Applied Mathematics and Modeling for Chemical Engineers", 2nd Edition, Wiley, 2012.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	3	3	-	3	-	-	-	-	-	-	-	1	2
CO2	3	3	3	-	3	-	-	-	-	-	-	-	1	2
CO3	3	3	3	-	3	-	-	-	-	-	-	-	1	2
CO4	3	3	3	-	3	-	-	-	-	-	-	-	1	2
CO5	3	3	3	-	3	-	-	-	-	-	-	-	1	2



CM23651	CHEMICAL PLANT DESIGN			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the basic on designing chemical process unit for rotary equipment.						
2	learn the operations of boilers, heat exchangers, refrigeration and air conditioners.						
3	knowledge on operations of distillation and other mass transfer operations.						
4	learn the different types of equipments in process industries.						
5	understand the knowledge on usage of pressure vessels.						
<b>UNIT I</b>	<b>ROTARY EQUIPMENT</b>						<b>9</b>
Pumps: Centrifugal – basic parts, pump selection, hydraulic characteristics, Suction head, discharge head, Velocity head, NPSH, Power requirements for pumping through process lines, steps in pump sizing, troubleshooting checklist factors in pump selection. Rotary pumps performance characteristics, Reciprocating pumps – performance and discharge flow patterns. Selection and Design procedure of compressors.							
<b>UNIT II</b>	<b>HEAT TRANSFER EQUIPMENT</b>						<b>9</b>
Heat Exchangers – Basic design procedure theory, overall heat transfer coefficient, fouling factors Shell and Tube – Construction details, mean temperature difference, general design considerations Shell and Tube side heat transfer coefficient with no phase change, Pressure drop single phase, Double Pipe, air-cooled and Plate heat exchangers, Fired heaters and boilers.							
<b>UNIT III</b>	<b>MASS TRANSFER EQUIPMENT</b>						<b>9</b>
Continuous Distillation columns – Process and basic principles, design variables, design methods for binary systems, Multicomponent distillation – Shortcut methods for stage and reflux requirements, Plate efficiency, Packed columns, General design procedure for liquid-liquid extraction, adsorption, drying and absorption.							
<b>UNIT IV</b>	<b>REACTORS</b>						<b>9</b>
Reactor Principles, types, Space velocity and time, chemical reaction rate expressions, Reaction and reactor performance – parallel, series reactions, Reactor and Catalyst equipment – Selection of catalyst, types of reactors, selection of reactors. Reactor design procedure, software, Costs for reactor equipment.							
<b>UNIT V</b>	<b>MATERIALS HANDLING EQUIPMENT</b>						<b>9</b>
Selection, costs and design procedures for agitators and mixers, Pressure Vessels – Codes and standards, fundamental principles and equations, general design considerations and procedures, Design of vessels subjected to external pressure and combined loading, Vessel supports, High-pressure vessels, Pressure relief devices.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	apply the basic on designing chemical process unit for rotary equipment.	Applying (K3)												
CO2	demonstrate the operations of boilers, heat exchangers, refrigeration and air conditioners.	Analyzing (K4)												
CO3	evaluate Knowledge on operations of distillation and mass transfer operations.	Analyzing (K4)												
CO4	compare the different ancillary equipments in process industries.	Applying (K3)												
CO5	apply the knowledge on usage of different pressure vessels.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Ernest E. Ludwig, "Applied Process Design for Chemical and Petrochemical Plants", 3rd Edition, Gulf Professional Publishing, 1995.														
2. Sinnott, R.K. and Towler, G., "Chemical Engineering Design, Principles, Practice and Economics of Plant and Process Design" Butterworth Heinemann, Elsevier, 2013.														
<b>REFERENCES</b>														
1. Subhabrata Ray and Gargi Das, "Process Equipment and Plant Design - Principles and Practices", 1 <sup>st</sup> Edition, Elsevier, 2020.														
2. K.S.N. Raju, "Fluid Mechanics, Heat Transfer, and Mass Transfer: Chemical Engineering Practice" Wiley, 2011.														
3. Sinnott, R.K., "Coulson and Richardson's Chemical Engineering Series: Chemical Engineering Design", Vol. VI, 4 <sup>th</sup> Edition, Elsevier Butterworth-Heinemann, 2005.														
4. Donald Q. Kern, "Process Heat Transfer", Second Edition, Wiley, 2019.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
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CO1	3	2	3	2	2	-	1	-	2	1	2	2	2	2
CO2	3	2	3	2	2	-	1	-	2	1	2	2	2	1
CO3	3	2	3	2	2	-	1	-	2	1	2	2	2	1
CO4	3	2	3	2	2	-	1	2	1	2	2	2	2	1
CO5	3	2	3	2	2	-	1	-	2	2	2	2	2	1



CM23652	<b>PLANT LAYOUT</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the importance of plant layout in mitigating risk on people, plant, Planet.						
2	understand the knowledge in placing equipment for ease of operability & maintainability						
3	understand the storage tanks operation and usage at safety level						
4	knowledge on usage of equipment at safety levels and their risk assessment						
5	understand the basic engineering design package						
<b>UNIT I</b>	<b>STANDARDS PRACTICES FOR INDUSTRIAL AREA PLANNING</b>						<b>9</b>
Standards for area classification – Electrical Area classifications, Occupational Safety and Health Administration (OSHA) regulations, National Fire Protection Association (NFPA), Petroleum Hazards Classification, IP15 Petroleum classification based on flash point, OISD standards (Oil Industry Safety Directorate), API Codes (American Petroleum Institute), PESO (Petroleum and Explosives Safety Organization) guidelines.							
<b>UNIT II</b>	<b>PLANT LOCATION AND LAYOUT</b>						<b>9</b>
Plant location and Site selection for process plants, Site conditions, Environmental checklist – Climate, Water pollution, Air pollution, noise and visual. Design procedure of plant layout, Information required for plant layout, Techniques used in site and plant layout. Utilities, Environmental considerations.							
<b>UNIT III</b>	<b>STORAGE TANKS</b>						<b>9</b>
Storage Tanks – Fixed or Floating roof, Mounded Bullet tanks, Cryogenic storage tanks with breather systems, Lightning arrestors, Earth pits, –Manways for roofs or tank sidewalls, Catwalks, Roof vents, Roof hatches, Nozzles, Roofs (flat-style, knuckle-style, or pitched), rainwater drains, dyke capacity, inter tank distance based on product hazard classification, tank inspection schedule, ease of cleaning, confined place entry, water spray and other firefighting feature, fugitive emission control, etc.							
<b>UNIT IV</b>	<b>RISK SYSTEMS AND EQUIPMENT</b>						<b>9</b>
Risk systems and equipment: Fuel gas systems, Fuel oil network, Hydrogen gas for generator cooling in power plants; Plant battery systems, Ammonia systems, Solid handling of coal and coke dust, Sulphur yard, Toxic gas loss of containment, MSDS of every stream being handled / processed, Spent catalyst safe disposal.							
<b>UNIT V</b>	<b>ENGINEERING DESIGN PHILOSOPHIES AND PRACTICES</b>						<b>9</b>
Design philosophies such as Operating & Control philosophy, Vent & Drain philosophy, Isolation philosophy, sparing philosophy etc. Raw material details (Capacity, conditions, logistics including receipt modes & storage criteria). Green belt cover, use of renewables, zero liquid discharge, maximum air cooling / condensing, storm water channel considerations, rain water harvesting ; Flare gas recovery, flight path and tall structures in industry premises.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	classify the standards and regulations of plant layout in mitigating risk	Analyzing (K4)												
CO2	apply knowledge in placing equipment for ease of operability & maintainability	Applying (K3)												
CO3	analyze different types of storage tanks operation and their safety usage	Analyzing (K4)												
CO4	apply the safety and risk parameters in the plant equipment	Applying (K3)												
CO5	design, operate and control philosophies in structures of industry.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Gavin Towler and Ray Sinnott, "Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design", Butterworth Heiniman publisher, 2008.														
2. Sinnott R.K., "Coulson and Richardson's Chemical Engineering Series: Chemical Engineering Design", Vol. VI, 4th Ed., Elsevier Butterworth-Heinemann, 2005.														
<b>REFERENCES</b>														
1. OISD Guideline on Plant Layout - OISD-STD-118														
2. OSHA Guidelines on Plant Layout														
3. API Guidelines on Plant layout														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
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CO1	2	1	2	1	2	1	1	1	1	1	2	2	2	2
CO2	2	1	2	2	2	1	1	1	1	1	2	2	2	2
CO3	2	1	2	2	2	1	1	1	1	1	1	2	2	2
CO4	2	1	1	2	2	1	1	1	1	1	2	2	2	2
CO5	2	1	2	2	2	1	1	1	1	1	1	2	2	2



CM23653	<b>DESIGN SAFETY</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	learn the safety systems both to prevent incident & to minimize loss.						
2	provide deep insight into the electrical systems in petroleum industries						
3	knowledge on flare systems and their safety						
4	get thorough knowledge on risk analysis and mitigation						
5	knowledge on the control systems and their safety usage in different process industries.						
<b>UNIT I</b>	<b>SAFETY SYSTEMS</b>						<b>9</b>
Pressure relief systems terminologies, Codes, Standards and guidelines, Relief types and Characteristics, Pressure Relief Devices, Sizing of pressure relief systems, Emergency relief effluent collection and handling, Equipment selection criteria and guidelines, Reliefs for vapors and as service, liquid service, thermal expansion of process fluids. Deflagration venting for dust and vapor explosions.							
<b>UNIT II</b>	<b>ELECTRICAL INSTRUMENTATION SYSTEMS</b>						<b>9</b>
Static electricity – Basic concepts, mechanism of charge generation in liquids and powders, accumulation of electrostatic charge, Various Electrostatic Discharge methods, Ignition of flammable vapors and Dusts, Earthing and Bonding, Examples for static Ignition.							
<b>UNIT III</b>	<b>FIRE SYSTEMS</b>						<b>9</b>
Types of fire – Pool, Jet, Vapor Cloud fire, Fireball. Size and shape of flames, Assessment of safety distance, Explosion mechanisms – Deflagration, Detonation. Condensed phase explosion, Formation of Explosive mixture – Ammonium Nitrate. Explosions in a chemical reaction, Dust and physical explosion.							
<b>UNIT IV</b>	<b>HAZARDS</b>						<b>9</b>
Chemical hazards – Analysis of Product and Process safety, HAZOP (Hazard and Operability Study), What-If Analysis, HAZAN (Hazard Analysis), EERA (Emergency escape route analysis), FMEA (Failure Modes And Effects Analysis), Fault tree and Event Tree analysis, Safety indices, safety checklists.							
<b>UNIT V</b>	<b>SAFETY STRATEGY</b>						<b>9</b>
Process safety strategies, Safe Operating procedures, Safe work practices – Hot work, Confined space entry. Designs for process safety – Emergency isolation valves, Double block and bleed, Safeguards and redundancy, Explosion suppression, Flame arrester, Containment. Design for runaway reactions. Accident Case studies – Bhopal, BPCL, LPG Import terminal Hindustan petroleum and IOCL – Causes, circumstances, consequences, lessons and recommendations.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to												<b>BT Mapped (Highest Level)</b>		
CO1	determine the safety systems both to prevent incident & to minimize loss											Analyzing (K4)		
CO2	plan the electrical safety systems in process criticalities											Applying (K3)		
CO3	categorize various flare systems and their safety											Analyzing (K4)		
CO4	prioritize risk mitigation measures based on hazard studies											Applying (K3)		
CO5	employ control systems with safety in process industries.											Applying (K3)		
<b>TEXT BOOKS</b>														
1. Daniel A Crowl, "Chemical Process Safety: Fundamentals with applications", Pearson, Third Edition, 2014.														
2. Samarendra Kumar Biswas, Umesh Mathur, "Fundamentals of process safety engineering", CRC Press, 2022.														
<b>REFERENCES</b>														
1. Aarti Kashayup, "Chemical Process Safety", Scitus publisher, 2015.														
2. Klein James A and Bruce K Vaughan, "Process Safety: Key Concepts and Practical approaches", CRC Press, 2020.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO2	2	2	3	3	2	1	1	1	1	2	2	2	2	2
CO3	2	2	3	3	3	1	1	1	1	2	1	1	2	2
CO4	2	2	3	3	3	1	1	1	1	1	2	2	2	2
CO5	2	2	3	2	2	1	1	1	1	2	2	2	2	2



CM23654	MATERIAL SELECTION			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	make the students understand materials selection, based on their properties and processing.						
2	enable the students, select the suitable materials based on their mechanical behavior.						
3	familiarize the students with the phase diagrams and phase transformation of materials.						
4	equip students with the knowledge on types and manufacturing of metals.						
5	develop students' skill in selection of materials required for processing in chemical industries.						
<b>UNIT I</b>	<b>INTRODUCTION</b>						<b>9</b>
Process of Material selection - Materials selection criteria, Procedure. Mandatory requirements Design conditions, temperatures, Process requirements, Special requirements, Material selection Diagram. Economic, Environmental and Societal Issues in Materials and Science Engineering - Recycling Issues, Bio-degradable and Bio-renewable materials.							
<b>UNIT II</b>	<b>PROPERTIES AND MATERIALS</b>						<b>9</b>
Material properties - mechanical properties such as tensile strength, stiffness, toughness, hardness, fatigue and creep. Effect of temperature on the mechanical properties. Material costs, Commonly used materials for construction, Plastics as construction for chemical plants – PVC, PTFE, PVDF and GRP, Ceramic materials, Carbon, Protective coatings.							
<b>UNIT III</b>	<b>FERROUS MATERIALS AND CORROSION</b>						<b>9</b>
Pig iron, Cast iron, Mild Steel - properties & Applications, Special Alloy steels - Stainless steel and High temperature steel. Binary phase diagrams - Iron- Iron Carbide Phase Diagram – Heat Treatment processes – Annealing, Normalizing, Quenching, Tempering and Surface hardening. Corrosion types – Uniform, Galvanic, Pitting and Intergranular corrosion.							
<b>UNIT IV</b>	<b>NON-FERROUS METALS AND COMPOSITES</b>						<b>9</b>
Manufacturing methods of Copper, Nickel, Aluminium and Magnesium alloys. Properties and applications in process industries. Composite – Fiber Reinforced Plastics (FRP), Particle reinforced composites, Structural composites, Wood and timber.							
<b>UNIT V</b>	<b>ADVANCEMENT IN MATERIAL SCIENCE</b>						<b>9</b>
Introduction to Nanotechnology - Characterization and Properties of Nano Materials – Applications of Nano Structures - use of graphene, metal organic framework, super conductors, replacement of Lithium for battery making, etc. Nano materials, needed to minimize dependence on import for some of the metals used in catalyst, defence needs, etc. which can only be substituted with effective end application needs and metallurgy and or alloy use.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	describe the fundamental concepts of crystalline and non-crystalline materials	Understanding (K2)												
CO2	explain the properties of materials and their failure mechanics	Understanding (K2)												
CO3	discuss the mechanical properties of various metal alloys using Phase Diagrams	Analyzing (K4)												
CO4	analyze the failures of materials under various loading conditions	Analyzing (K4)												
CO5	discuss the criteria for material selection using case studies	Applying (K3)												
<b>TEXT BOOKS</b>														
1. William D Callister and David G Rethwisch, "Callister's Materials Science and Engineering", 10th Edition, John Wiley & Sons Inc, 2020.														
2. David A Hansen, Robert B Puyear, "Material Selection for Hydrocarbon and Chemical Plants", 1st Edition, Taylor and Francis Group, 1996.														
<b>REFERENCES</b>														
1. James A. Lee, "Materials of Construction for Chemical Process Industries", Mc Graw Hill, 1950														
2. Frank Rumford, "Chemical Engineering Materials", Nabu Press, 2013.														
3. O P Khanna, "Material Science and Metallurgy", Dhanpat rai publications														
4. R K Rajput' "Engineering Materials", S Chand publications, 2020.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO1	3	2	1	1		1				1	1	2	2	3
CO2	2	2	1	1		1				1	1	2	2	3
CO3	3	2	1	1		1				1	1	2	2	3
CO4	3	2	1	1		1				1	1	2	2	3
CO5	3	2	1	1		1				1	1	2	2	3



<b>CM23655</b>	<b>STATUTORY REQUIREMENTS AND CUSTOMER CARE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the purpose of competitive edge within the regulatory systems set.				
2	learn about the importance of environmental regulations				
3	understand the concepts of Net Zero Concept				
4	leverage learning to become SMART manufacturer				
5	learn about the importance and norms of responsive care.				
<b>UNIT I</b>	<b>PEOPLE AND PROCESS SAFETY</b>				<b>9</b>
Factory Act, IBR (Indian Boiler Regulations), Weights and Measures, Power Connection from State Electricity Board, Labour Legislation, Compensation, Fines, Litigations, Image, etc. and other commercial approvals like company registration, GST Registration, IT act, Excise Regulations.					
<b>UNIT II</b>	<b>ENVIRONMENTAL REGULATIONS</b>				<b>9</b>
Water act, Air act, for highly polluting industry category EIA (Environment Impact Assessment) is mandatory, Environmental Protection Act, License needed for 'Drugs & Pharmaceuticals' from State Drug Controller, Hazardous substance management, Waste Management rules, Pollution Control Boards, Consent to operate (State and Union Government) specially for Industries Requiring Water and Affecting Effluent Disposal.					
<b>UNIT III</b>	<b>CUSTOMER CARE</b>				<b>9</b>
Customer definition, Kano Model, CRM, PFABFS model (Property, Feature, Advantage, Benefit and Savings both monetary and emotional value); Product Supply Specification based on end use applications with competitive edge over peer industries; Quality Cost, Custody transfer precision, Wing to Wing co-operation with customers / suppliers to enhance value chain returns; Development of new products and services – Ideation, proof of concept, pilot run & commercialization.					
<b>UNIT IV</b>	<b>INTERNSHIP PREPARATION AND DO'S &amp; DON'TS</b>				<b>9</b>
Safety Contact, Mandatory use of PPE, Assembly points, Alarm station, Mock drills, Firefighting apparatus use on demand, know the escape routes; Shadow the trainer, learning objective – pick any one viz. Catalysis – past say three to five catalyst change, the conversion variation, generation of low value side reactions, sintering & loss of margin, H <sub>2</sub> loss, any tell-tale indications from apple core tests of spent catalyst.					
<b>UNIT V</b>	<b>SUSTAINABILITY REPORTING</b>				<b>9</b>
Understanding aspects like 'Net Zero Concept', Green House Gases release reduction, ZLD (zero Liquid discharge), Benefits to the society, Concepts of linear economy and circular economy, Life Cycle Analysis, Think Global and Act Local, learn on 17 Sustainable Development Goals as per UN charter, Use Global Reporting Initiative (GRI) formats for Sustainability reporting.					
<b>TOTAL PERIODS</b>					<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	apply the basis on different acts and their regulations	Analyzing (K4)												
CO2	demonstrate knowledge in different ACT on water, air and environmental protection	Applying (K3)												
CO3	evaluate knowledge on the preparation of Kano model, CRM, PFABFS	Analyzing (K4)												
CO4	discuss on Do's and Don'ts in an internship program	Applying (K3)												
CO5	apply the concepts of ZLD, GHG release and circular economy	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Todd Zenger, "Beyond Competitive Advantage", Harvard Business School Publishing, 2016.														
2. Michael E. Porte, "Competitive Advantage: Creating and Sustaining Superior performance", 2017.														
<b>REFERENCES</b>														
1. Paul B. Thompson, Patricia E. Norris, "Sustainability What Everyone Needs to Know", 2021.														
2. DOs and DON'Ts to Make the Most of Your Internship (twc.edu)														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and            Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
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CO3	2	2	2	2	2	1	1	1	2	2	2	2	2	2
CO4	2	-	-	-	2	1	1	1	2	2	1	2	2	2
CO5	2	-	1	2	2	1	1	1	2	1	2	2	2	2



CM23656	PROCESS PLANT UTILITIES			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	provide a comprehensive understanding of industrial water requirements.						
2	familiarize with the performance characteristics and applications of compressors and vacuum pumps, lubrication, and moisture removal techniques.						
3	introduce the principles of refrigeration and ventilation systems, different refrigeration cycles and the production of cryogenic temperatures.						
4	equip with knowledge on types of steam generators, and techniques to address scaling and corrosion in boilers.						
5	highlight the importance of insulation techniques and materials in various industrial processes, for different temperature ranges for process effectiveness.						
<b>UNIT I</b>	<b>INDUSTRIAL WATER</b>						<b>9</b>
Hard and Soft water, Requisites of Industrial Water and its uses. Chemical Softening and Demineralization - lime-soda process, zeolite and ion-exchange process, Resins used for Water Softening, Treatment of Boiler feed water, Re-use and conservation of water.							
<b>UNIT II</b>	<b>COMPRESSORS AND PUMPS</b>						<b>9</b>
Compressors and Vacuum pumps- Performance characteristics of Compressor and pumps – centrifugal, reciprocating and vacuum. Piping systems. Air leaks. Lubrication requirements types such as splash, forced-feed. Oil and moisture removal – sources, removal methods such as coalescing filters, refrigerated dryers and desiccant dryers.							
<b>UNIT III</b>	<b>REFRIGERATION AND VENTILATION</b>						<b>9</b>
Principles of refrigeration, refrigeration systems - vapor compression (compressor, condenser, expansion valve) and vapor absorption (absorber and heat pump) cycles, types of refrigerants, classification, importance and safety standards. Production of cryogenic temperatures. Exhaust Ventilation – air flow calculation, duct sizing, importance of HVAC.							
<b>UNIT IV</b>	<b>STEAM GENERATION</b>						<b>9</b>
Properties of Steam, Types of Steam Generator such as Solid Fuel Fired Boiler, Waste Gas Fired Boiler and Fluidized Bed Boiler. Scaling and Corrosion in boiler and Trouble Shooting. Boiler mounting and accessories, Boiler act.							
<b>UNIT V</b>	<b>INSULATION</b>						<b>9</b>
Importance of insulation for meeting the process requirement, insulation materials and their effect on various material of equipment piping, fitting and valves etc. insulation for high intermediate, low and subzero temperatures, including cryogenic insulation.							
						<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES		BT Mapped (Highest Level)												
At the end of this course, students will be able to														
CO1	determine the importance of process utility and recognize importance of treatment and conservation of water.	Analyzing (K4)												
CO2	explain the various types of compressors and vacuum pumps, piping systems used in industries.	Applying (K3)												
CO3	identify the role of refrigerant for different refrigeration systems and their importations, ventilation systems.	Analyzing (K4)												
CO4	outline the basic properties of steam along with their generation and utilization of steam in process plants.	Analyzing (K4)												
CO5	examine the suitable insulation for different materials piping, fittings and valves.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Goodall P.M., "The efficient use of steam", IPC Science and Technology, 1980.														
2. Ashutosh Pande, "Plant Utilities", Vipul Prakashan, Mumbai. 1999.														
<b>REFERENCES</b>														
1. Perry, R.H., and Green, D.W, "Perry's Chemical Engineers Handbook", Eighth Edition, McGraw Hill (ISE), 2008														
2. Nordell, Eskel, "Water treatment for industrial and other uses", Reinhold publishing corporation, Newyork.(1961).														
3. D.B. Dhone, "Plant Utilities" Nirali Prakashan Publication, 2018.														
4. Dr. Mujawar, "Plant Utilities" Nirali Prakashan Publication.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	-	-	-		1	1	1	1		2	2	2	2
CO2	2	2	2	2		1	1	1	1		2	2	2	2
CO3	2	2	2	2		1	1	1	1		2	2	2	2
CO4	2	2	2	2		1	1	1	1		2	2	2	2
CO5	2	2	2	2		2	1	1	1		2	2	2	2



CM23657	PROCESS ECONOMICS AND MANAGEMENT	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the cost estimation methods and cash flow for industrial operations				
2	know the taxes, depreciation and alternatives in a project.				
3	understand the estimation procedure for capital investment and expenses				
4	know the principles of organization and communication				
5	identify the production and quality measurement techniques				
<b>UNIT I</b>	<b>COST ESTIMATION</b>				<b>9</b>
Cash flow for industrial operations, Factors affecting investment and production costs, Estimation of fixed capital investment - Cost estimation - cash flow for industrial operations - tree diagram - cumulative cash position - factors affecting investment and production costs					
<b>UNIT II</b>	<b>PROFITABILITY</b>				<b>9</b>
Types of taxes – Taxable income – Capital gain tax, State tax – Depreciation salvage value - present value – recovery period - Methods for calculating depreciation - Straight-Line Method – Declining - Balance method – Sinking - Fund Method. Break even analysis. Methods for calculating profitability, choice between alternatives and replacement.					
<b>UNIT III</b>	<b>CAPITAL INVESTMENTS</b>				<b>9</b>
Land, Capital Investment – Fixed, Total and Working Capital - estimation of capital investment - Types of capital cost estimates - Cost Indexes in capital investment- estimating equipment costs by scaling - Methods for estimating capital investment – Contingency, Offsite capital, Allocated capital, Working capital and Start-up expenses.					
<b>UNIT IV</b>	<b>MANAGEMENT AND ORGANIZATION</b>				<b>9</b>
Organization – Objectives, Process, Principles. Types of Organization, Process of Directing – Communication elements, types and principles of effective communication. Motivation – Leadership styles, types. Process of Coordinating and controlling.					
<b>UNIT V</b>	<b>PRODUCTION AND QUALITY</b>				<b>9</b>
Work system design- Method study – Identification, Recording, Examination, Development and Installation. Working Measurement techniques, Forecasting – General steps, Sales forecast, Methods of forecasting. Inventory – objectives, classification, factors affecting inventory and inventory modeling and functions of inventory. Quality management and organization, Acceptance sampling, Process control – Seven QC tools, Control chart, X and R Charts and use of computer in quality control.					
<b>TOTAL PERIODS</b>					<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	apply the aspects of cost accounting for industrial operations	Analyzing (K4)												
CO2	calculate the taxes and depreciation employing diverse methods	Applying (K3)												
CO3	estimate the capital cost investment during selection and replacement of equipment	Analyzing (K4)												
CO4	apply the principles of organization in the process of controlling	Applying (K3)												
CO5	analyze the principles of work system, forecasting and quality management	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Peter and Timmerhaus, "Plant Design and economics for Chemical Engineers", 5 <sup>th</sup> Edition Reprint, Mc Graw Hill Book Co, New York, 2017.														
2. James R Cooper, "Process Engineering Economics", CRC Press, 2003.														
<b>REFERENCES</b>														
1. Harry Silla, "Chemical Process Engineering: Design and Economics", 1 <sup>st</sup> Edition, CRC press, USA, 2003.														
2. Sivasubramanian V, "Process Economics and Industrial Management", 1 <sup>st</sup> Edition, New Delhi, Galcotia Publishers, 2008.														
3. Mahajani, V.V., "Chemical Project Economics", Macmillan Indian Ltd., New Delhi, India, 2005.														
4. Gavin Towler and Ray Sinnott, "Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design", Butterworth Heiniman publisher, 2008.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b>														
<b>(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak</b>														
	<b>PO's</b>												<b>PSO's</b>	
<b>CO's</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>1</b>	<b>2</b>
<b>CO1</b>	1	1	2		1						3	2	1	2
<b>CO2</b>	1	1	2		1						3	2	2	2
<b>CO3</b>	3	2	1		2						3	2	2	2
<b>CO4</b>	3	2	1		2						3	2	1	1
<b>CO5</b>	3	2	1		2						3	2	2	1



CM23851	<b>HAZARDOUS WASTE MANAGEMENT</b>	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	identify and classify hazardous, biomedical, radioactive, and e-waste types as per Indian standards.				
2	explain waste handling, storage, and transport procedures with regulatory compliance.				
3	describe treatment and disposal methods like physical, chemical, thermal, and biological processes.				
4	apply standard practices for biomedical and radioactive waste treatment and disposal.				
5	analyze e-waste management techniques including recycling, recovery, and safe disposal.				
<b>UNIT I</b>	<b>INTRODUCTION TO HAZARDOUS WASTE AND REGULATIONS</b>				<b>9</b>
Definition and classification of hazardous waste – Regulatory aspects of hazardous waste management in India including CPCB guidelines and Hazardous and Other Wastes (Management and Transboundary Movement) Rules – Sources and types of hazardous waste such as industrial, chemical, and agricultural – Characterization of hazardous waste based on physical and chemical properties – Categories of hazardous waste under Indian laws – Environmental transport of hazardous substances through air, water, and soil – Introduction to hazard assessment models and ranking systems.					
<b>UNIT II</b>	<b>HAZARDOUS WASTE HANDLING, TREATMENT, AND DISPOSAL</b>				<b>9</b>
Safe handling, collection, storage, and transportation procedures for hazardous waste – Concept and layout of Treatment, Storage and Disposal Facilities (TSDF) in India – Physical treatment techniques such as filtration, sedimentation, and evaporation – Chemical treatment methods including neutralization, oxidation-reduction, and precipitation – Thermal treatment methods like pyrolysis and incineration – Solidification, encapsulation, and chemical fixation techniques – Biological treatment options like aerobic and anaerobic digestion – Hazardous waste landfill site selection, design, and operational considerations – Waste minimization strategies, recycling, and resource recovery – Hazardous site remediation methods including in-situ and ex-situ techniques.					
<b>UNIT III</b>	<b>BIOMEDICAL WASTE MANAGEMENT</b>				<b>9</b>
Definition and sources of biomedical waste from hospitals, clinics, labs, and veterinary facilities – Regulatory framework under the Biomedical Waste Management Rules, 2016 and amendments – Classification of biomedical waste with standard color-coded segregation and labeling practices – Handling and collection procedures – Treatment techniques including autoclaving, incineration, and chemical disinfection – Final disposal methods like deep burial and secured landfills – Infection control protocols and safety guidelines for healthcare workers in Indian hospitals.					
<b>UNIT IV</b>	<b>RADIOACTIVE WASTE MANAGEMENT</b>				<b>9</b>
Definition and classification of radioactive waste (LLW, HLW, TRU) – Measurement and monitoring of radiation using detectors and dosimeters – Sources of radioactive waste including nuclear reactors, research institutions, and medical facilities – Biological and environmental impacts of radiation – Waste management techniques such as cementation, vitrification, and deep geological disposal – Management of uranium mine tailings and reactor waste – Indian regulations and standards issued by ICRP, AERB, and BARC for radioactive waste handling and disposal.					
<b>UNIT V</b>	<b>E-WASTE MANAGEMENT &amp; RESOURCE RECOVERY</b>				<b>9</b>
Definition and overview of e-waste – Regulatory framework under India's E-Waste Management Rules – Sources of e-waste from household electronics, IT equipment, and mobile devices – Material composition including precious metals, plastics, and toxic components – Collection mechanisms, extended producer					

responsibility (EPR), and informal recycling practices in India – Treatment techniques including dismantling, separation, shredding, and chemical recovery – Safe disposal methods for residual e-waste – Integrated approaches to e-waste management and circular economy principles – Emerging technologies such as urban mining and AI-supported segregation.	<b>TOTAL PERIODS</b>	<b>45</b>
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<b>COURSE OUTCOMES</b>		<b>BT Mapped (Highest Level)</b>
At the end of this course, students will be able to		
CO1	analyze characteristics and transport routes of hazardous waste	Analyzing (K4)
CO2	apply concepts of hazardous waste planning and management	Applying (K3)
CO3	analyze the significance of hazardous waste management practices	Analyzing (K4)
CO4	understand physico-chemical treatment methods like incineration	Understanding (K2)
CO5	apply principles of hazard analysis	Applying (K3)

- TEXT BOOKS**
1. Charles A. Wentz, "Hazardous waste management" Second edition, McGraw Hill, 1995.
  2. Michael D. La Gerga, Philip L. Buckingham, Jeffrey C. Evans, "Hazardous waste management", Second edition, Waveland Press, 2010.

- REFERENCES**
1. William C. Blackman Jr, "Basic Hazardous waste management", Third Edition, Lewis Publishers, 2001,
  2. George Tchobanoglous, Hilary Theisen & Samuel A. Vigil, "Integrated solid waste management", McGraw Hill, 1993.
  3. Harry M. Freeman, "Standard handbook of Hazardous waste treatment and disposal" McGraw Hill 1997.
  4. Frank Flint off, "Management of Solid waste in developing countries", WH Original publication.

**CO-PO MAPPING :**

**Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	1	2	1	2	2	1	2	1	2	3	2	1	2	1
CO2	1	1		2	1	2	1	2	1	2	1	1	2	1
CO3	1	3	2	2	1		1	1	1		1	2		1
CO4	2	2		2	1	2	1	1	2	2	1	2	2	1
CO5	3	1	2		2	1	2	1	1		1	1	2	1



CM23852	<b>BIOTECHNOLOGY FOR WASTE MANAGEMENT</b>	3	0	0	3
<b>COURSE OBJECTIVES</b>	Understand the type, nature and treatment of hazardous wastes.				
To enable the students to					
1	understand the fundamentals of biological processes used for waste treatment.				
2	identify types of biomass and apply techniques for value addition through bioconversion.				
3	explore sustainable energy production methods from various waste materials.				
4	understand microbial and enzymatic production of chemicals and enzymes from waste.				
5	learn composting principles and evaluate factors influencing compost quality				
<b>UNIT I</b>	<b>BIOLOGICAL TREATMENT PROCESS</b>	<b>9</b>			
Overview of biological waste treatment – Principles of anaerobic and aerobic digestion – Pretreatment methods to enhance anaerobic performance – Comparison of aerobic, anaerobic, and anoxic systems – Role of environmental and operational factors in microbial activity – Introduction to solid-state and submerged fermentation – Modes of fermentation: batch and continuous systems – Applications in organic waste degradation.					
<b>UNIT II</b>	<b>WASTE BIOMASS AND ITS VALUE ADDITION</b>	<b>9</b>			
Classification and nature of biomass from agricultural, industrial, and municipal sources – Solid waste management principles – Introduction to bio-based economy – Techniques for biomass valorization – Biotransformation of plant and marine biomass – Direct extraction of biochemicals – Industrial applications of plant-derived biomass – Role of microbial and enzymatic processes in value addition.					
<b>UNIT III</b>	<b>BIOCONVERSION OF WASTES TO ENERGY</b>	<b>9</b>			
Concept and scope of bioenergy from waste – Production of bioethanol, biohydrogen, and biobutanol through fermentation – Photo and dark fermentative pathways – Biogas and biomethane generation through single-stage and two-stage anaerobic digestion – Biodiesel production using waste oils – Enzymatic hydrolysis as a key enabling technology – Role of microbes and process integration in energy recovery.					
<b>UNIT IV</b>	<b>CHEMICALS AND ENZYMES FROM WASTES</b>	<b>9</b>			
Microbial and enzymatic production of industrial chemicals – Synthesis of lactic acid, succinic acid, and citric acid – Biopolymer formation from renewable substrates – Enzyme recovery from lignocellulosic waste – Production of industrial enzymes such as amylases, proteases, pectinases, lipases – Importance of fermentation parameters and downstream processing.					
<b>UNIT V</b>	<b>BIOCOMPOSTING OF ORGANIC WASTES</b>	<b>9</b>			
Fundamentals and benefits of composting – Microbial role in decomposition and nutrient cycling – Parameters influencing composting efficiency (C/N ratio, moisture, aeration) – Materials suitable for					



composting – Technologies: reactor-based and non-reactor systems – Quality control of compost – Applications in soil conditioning and waste recycling.		
		<b>TOTAL PERIODS</b>   45

<b>COURSE OUTCOMES</b>		<b>BT Mapped (Highest Level)</b>
At the end of this course, students will be able to		
CO1	explain and compare biological treatment processes (aerobic, anaerobic, anoxic).	Analyzing (K4)
CO2	identify biomass types and apply biotransformation and value addition techniques.	Applying (K3)
CO3	analyze bioenergy production methods from waste biomass.	Analyzing (K4)
CO4	understand the microbial and enzymatic production of chemicals and enzymes from waste.	Understanding (K2)
CO5	evaluate composting techniques and quality control of bio-compost.	Applying (K3)

**TEXT BOOKS**

1. Antoine P. T., “Biofuels from Food Waste Applications of Saccharification Using Fungal Solid State Fermentation”, CRC press, 2017.
2. Joseph C A., “Anaerobic Waste-Wastewater Treatment and Biogas Plants-A Practical Handbook”, CRC Press, 2019.

**REFERENCES**

1. Palmiro P. and Oscar F.D’Urso, ‘Biotransformation of Agricultural Waste and By-Products’, The Food, Feed, Fibre, Fuel (4F) Economy, Elsevier, 2016.
2. Kaur Brar S., Gurpreet Singh D. and Carlos R.S., (Eds), ‘Biotransformation of Waste Biomass into High Value Biochemicals’, Springer, 2014.
3. Keikhosro K, Editor, ‘Lignocellulose-Based Bioproducts’, Springer, 2015.
4. John P, ‘Waste Management Practices-Municipal, Hazardous, and Industrial’, Second Edition, CRC Press, 2014.

**CO-PO MAPPING :**

<b>Mapping of Course Outcomes (CO’s) with Programme Outcomes (PO’s) and Programme Specific Outcomes (PSO’s)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO’s	PO’s												PSO’s	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	1	2		1	3	1	2	3	2	1	2	2
CO2	1		1	1	1	2	1	2		2	1		2	2
CO3		2	2		1	2			1	1		2	1	2
CO4	2	2		2		2	2		2	2	2	2	2	1
CO5	3	1	2	1	2	1				2	2	1	2	1



CM23853	WASTE TO ENERGY CONVERSION	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the importance and methods of waste-to-energy (WTE) conversion.				
2	learn waste characterization techniques and evaluate its energy potential.				
3	gain knowledge of various thermal, biological, and mechanical waste conversion technologies.				
4	identify pollution sources and apply control strategies in WTE systems.				
5	evaluate the environmental impact, sustainability, and feasibility of WTE projects.				
<b>UNIT I</b>	<b>INTRODUCTION TO WASTE MANAGEMENT AND ENERGY CONVERSION</b>				<b>9</b>
Overview of solid waste management – Significance of waste-to-energy conversion in sustainable development – Classification and sources of waste: municipal, agricultural, industrial, biomedical – Principles of WTE – Types of energy recovery: thermal, biological, and mechanical – Pre-treatment techniques: drying, milling, grinding – Importance of moisture control and size reduction – Safe waste storage and handling practices – Hazards associated with various waste types.					
<b>UNIT II</b>	<b>WASTE CHARACTERIZATION AND ANALYSIS</b>				<b>9</b>
Physical, chemical, and biological properties of waste – Techniques for determining waste composition: proximate and ultimate analysis – Calorific value determination – Laboratory and field sampling methods – Energy content estimation for thermal processing – Introduction to the 3R principles (Reduce, Reuse, Recycle) – Volume and weight reduction strategies – Densification techniques: piston press, screw press, roll press – Design and optimization of waste collection and transportation systems.					
<b>UNIT III</b>	<b>WASTE CONVERSION TECHNOLOGIES</b>				<b>9</b>
Thermal conversion: incineration – principles, design, efficiency – Pyrolysis: types, gas and oil products – Gasification: air/oxygen-based, syngas production – Biological conversion: anaerobic digestion – biogas systems, digesters, operating parameters – Fermentation: ethanol and organic acid recovery – Composting and vermiculture: microbiology, process control, reactor designs – Integration of multiple WTE technologies for hybrid systems.					
<b>UNIT IV</b>	<b>POLLUTION CONTROL IN WTE FACILITIES</b>				<b>9</b>
Sources of emissions and pollutants: particulate matter, SO <sub>x</sub> , NO <sub>x</sub> , dioxins, heavy metals – Impact of pollution on human health and environment – Air pollution control devices: working principles and design of cyclone separators, electrostatic precipitators (ESP), baghouse filters, wet and dry scrubbers – Maintenance, cleaning, and efficiency optimization of control systems – Monitoring techniques and emission standards for WTE plants.					
<b>UNIT V</b>	<b>ENVIRONMENTAL IMPACT, CASE STUDIES AND APPLICATIONS</b>				<b>9</b>
Environmental effects of WTE systems: air, water, soil – Life cycle assessment (LCA): tools, input-output analysis, interpretation – Carbon footprint and GHG emissions from WTE – Sustainability					

indicators and energy balance – Economic evaluation: cost-benefit analysis, return on investment – National policies and government schemes on WTE – Real-world case studies of successful WTE implementation – Applications in power generation, cement industry, district heating, and industrial fuel substitution.	<b>TOTAL PERIODS</b>	<b>45</b>
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<b>COURSE OUTCOMES</b>		<b>BT Mapped (Highest Level)</b>
At the end of this course, students will be able to		
CO1	explain the importance of waste-to-energy conversion in the context of sustainability.	Analyzing (K4)
CO2	determine waste composition and evaluate its energy potential using standard techniques.	Applying (K3)
CO3	analyze various waste conversion technologies and suggest appropriate applications.	Analyzing (K4)
CO4	identify pollution sources in WTE systems and recommend suitable control strategies.	Understanding (K2)
CO5	outline the concepts of environmental impact and sustainability for WTE project evaluation.	Applying (K3)

**TEXT BOOKS**

1. Marc J. Rogoff, Francois Screve, “Waste-to-Energy: Technologies and Project Implementation” 2nd Edition, Elsevier Science, UK, 2011.
2. Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, John Wiley & Sons, USA, 2010.

**REFERENCES**

1. Naomi B Klinghoffer, Marco J Castaldi, “Waste to Energy Conversion Technology” Woodhead Publishing Limited, UK, 2013.
2. Frank Kreith, George Tchobanoglous, Handbook of Solid Waste Management, 2nd Edition, McGraw-Hill Education, USA, 2002.

**CO-PO MAPPING :**

**Mapping of Course Outcomes (CO’s) with Programme Outcomes (PO’s) and Programme Specific Outcomes (PSO’s)**  
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO’s	PO’s												PSO’s	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	–	–	–	2	3	–	–	1	–	2	2	1
CO2	3	3	–	2	2	–	2	–	–	–	–	2	3	2
CO3	3	3	3	–	2	–	3	–	–	–	–	2	3	2
CO4	2	2	–	–	2	2	3	–	–	–	–	1	2	1
CO5	2	2	2	2	2	2	3	1	–	1	2	3	3	2



CM23854	<b>SUSTAINABLE MATERIAL AND ELECTRONIC WASTES RECYCLING</b>			3	0	0	3
<b>COURSE OBJECTIVES</b>							
To enable the students to							
1	understand the principles of sustainable materials recycling and the importance of zero-waste approaches.						
2	gain knowledge on various waste characterization techniques used in material recycling.						
3	learn about recycling methods for industrial metal wastes and electronic waste streams.						
4	apply metallurgical and chemical processing technologies for metal and e-waste recycling.						
5	explore and evaluate emerging and advanced technologies in waste separation and recovery.						
<b>UNIT I</b>	<b>INTRODUCTION TO MATERIALS RECYCLING AND WASTE MANAGEMENT</b>						<b>9</b>
Overview of waste management and the concept of sustainable materials recycling – Categories of metallurgical and electronic wastes – Waste as a resource and zero-waste strategies – Unit operations in pre-treatment: size reduction, separation, and sorting – Introduction to pyro metallurgy, hydrometallurgy, electro metallurgy – Refining methods for material separation – Recovery of base and precious metals – Enrichment techniques for resource recovery.							
<b>UNIT II</b>	<b>WASTE CHARACTERIZATION TECHNIQUES</b>						<b>9</b>
Overview of waste characterization – Importance in resource recovery – Spectroscopic techniques: FTIR, UV-Vis, and Infrared Spectroscopy – Surface analysis by SEM and electron microprobe (EPMA) – Structural analysis by XRD – Trace analysis by PIXE – On-line identification systems for recyclable materials – Environmental testing and compliance monitoring – Application of characterization in optimizing recycling processes.							
<b>UNIT III</b>	<b>METAL WASTE RECYCLING</b>						<b>9</b>
Sources and classification of industrial metal wastes – Aluminium waste: dross, scrap, red mud, salt slag, and SPL – Copper waste: smelter slag, raffinates, spent electrolytes – Zinc waste: zinc ash, dross, flue dust – Approaches to recovery: physical, thermal, and chemical – Process integration and pollution control in metal recycling – Economic and environmental aspects.							
<b>UNIT IV</b>	<b>ELECTRONIC WASTE RECYCLING</b>						<b>9</b>
Types of electronic waste: PCB, batteries, and electronic assemblies – E-waste pre-treatment: dismantling, crushing, delamination – Recovery of metals from waste PCBs – Spent battery recycling: lithium, cobalt, and nickel extraction – Environmental risks and mitigation – Life cycle of electronic components and end-of-life management – Regulatory framework and e-waste guidelines in India.							
<b>UNIT V</b>	<b>EMERGING TECHNOLOGIES IN WASTE RECYCLING AND SEPARATION</b>						<b>9</b>
Introduction to advanced and green recycling techniques – Magnetic carrier-based separation – Silica-polyamine and molecular recognition-based separations – Magnetic fluids for selective extraction –							

Mesoporous adsorbents for heavy metals – Liquid membrane technologies – Nano filtration in waste valorization – Double Membrane Electrolytic Cell (DMEC) – Air-assisted solvent extraction – Application case studies in metal and e-waste recovery.	<b>TOTAL PERIODS</b>	<b>45</b>
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<b>COURSE OUTCOMES</b>		<b>BT Mapped (Highest Level)</b>
At the end of this course, students will be able to		
CO1	analyze opportunities and principles behind sustainable metal and e-waste recycling.	Analyzing (K4)
CO2	apply material characterization techniques for analyzing waste streams.	Applying (K3)
CO3	analyze materials flow and estimate waste generation in industrial systems.	Analyzing (K4)
CO4	apply recycling technologies like pyro, hydro, and bio hydrometallurgy for material recovery.	Applying (K3)
CO5	apply emerging separation technologies for effective waste treatment and resource recovery.	Applying (K3)

#### TEXT BOOKS

1. Palmiro P. and Oscar F.D'Urso, "Biotransformation of Agricultural Waste and By-Products", The Food, Feed, Fibre, Fuel (4F) Economy, Elsevier, 2016.
2. Daniel Ogochukwu Okanigbe, Abimbola Patricia Popoola, "Resource Recovery and Recycling from Waste Metal Dust", Springer Cham, Edition 1, 2023.

#### REFERENCES

1. Electronic Waste Recycling Techniques, Hugo Marcelo Veit and Andrea Moura Bernardes, Topics in Mining, Metallurgy and Materials Engineering, Springer International Publishing Switzerland, 2020

#### CO-PO MAPPING :

#### Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak

CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	3	2	–	–	1	2	3	–	–	–	–	2	2	1
CO2	3	3	–	2	3	–	2	–	–	–	–	2	3	2
CO3	3	3	2	2	2	2	3	–	–	–	–	2	3	2
CO4	2	2	3	–	3	–	3	–	–	–	–	1	3	2
CO5	2	2	2	2	3	2	3	1	–	1	1	3	3	2



CM23855	MANAGEMENT OF HOSPITAL WASTE	3	0	0	3	
<b>COURSE OBJECTIVES</b>						
To enable the students to						
1	gain knowledge on hospital waste					
2	know the waste regulation in India					
3	know the infections and sterilization methods					
4	understand various hospital waste disposal methods					
5	execute risk identification and assessment in hospital waste					
<b>UNIT I</b>	<b>INTRODUCTION TO HOSPITAL WASTES</b>				<b>9</b>	
Hospital waste: classification and types – Sources of biomedical, chemical, sharps, infectious, and pathological waste – Categories as per Biomedical Waste Management Rules, 2016 – Waste audit and estimation – Health and environmental impacts of hospital waste – Waste segregation and colour-coded bin system – Key elements of a hospital waste management plan.						
<b>UNIT II</b>	<b>WASTE REGULATION IN INDIA</b>				<b>9</b>	
Overview of Environmental Protection Act, Water Act, and Air Act – Biomedical Waste Management Rules, 2016 and amendments – Roles of CPCB and SPCB – Responsibilities of healthcare facilities – Regulatory compliance, permits, labeling, and manifest system – Transboundary waste movement – NABH, WHO, and global regulatory frameworks.						
<b>UNIT III</b>	<b>STERILIZATION TECHNIQUES</b>				<b>9</b>	
Types of healthcare-associated infections (HAIs) – Transmission of pathogens via biomedical waste – Chemical disinfectants: hypochlorite, phenol, glutaraldehyde – Physical methods: autoclave, dry heat, microwave, ultraviolet – Advanced sterilization: EtO, plasma sterilization – Monitoring and validation of disinfection systems – Infection control and use of personal protective equipment (PPE).						
<b>UNIT IV</b>	<b>WASTE DISPOSAL METHODS</b>				<b>9</b>	
Waste handling, storage, internal transportation practices – Packaging and barcoding of biomedical waste – Solid and liquid waste treatment: incineration, encapsulation, deep burial, autoclaving – Handling cytotoxic, chemical, and radioactive waste – On-site vs off-site treatment and common biomedical waste treatment facilities (CBWTFs) – Liquid waste pre-treatment before discharge – Waste reduction strategies and cleaner production in hospitals.						
<b>UNIT V</b>	<b>SAFETY AND RISK ASSESSMENT</b>				<b>9</b>	
Risk identification, hazard analysis, and control strategies – Emergency response and accident reporting – Occupational safety and health protocols – Fire and chemical handling in waste areas – Case studies of waste mismanagement incidents – Environmental monitoring near waste treatment areas – Green hospitals and sustainable biomedical waste practices.						
					<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	analyze the importance of handling and disposal of hospital waste.	Analyzing (K4)												
CO2	apply knowledge of Indian regulatory frameworks for hospital waste management.	Applying (K3)												
CO3	analyze the infection risks and identify challenges in managing infectious waste.	Analyzing (K4)												
CO4	understand various methods used for disposing of different types of hospital waste.	Understanding (K2)												
CO5	apply risk identification and safety practices in hospital waste management.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. C.R.BRUNNER, Medical Waste Disposable Handbook, Incentrated, Consultant in Corporated, Virginia, 2000.														
2. Tarannum Dana, Medical Waste Management, July 2012.														
<b>REFERENCES</b>														
1. Madhurisharma, Hospital waste Management and its Monitoring, Jaypee Brothers Medical publishers, second Edition February 2017.														
2. D.B. Acharya, Meet singh, The book of Hospital Management, Minerva Press, 2007.														
3. Dr. Shahnawaz Hamid, A Handbook on Biomedical Waste: National and International Overview, Notion Press; 1st edition, 2019														
4. Mohammad Mohsin, Hospital waste management, VDM Publishing, 2013														
5. Mohd. Faisal Khan, Hospital waste Management: Principles and Guidelines, Kanishka Publishers, 2010.														
<b>CO-PO MAPPING :</b>														
<b>Mapping of Course Outcomes (CO's) with Programme Outcomes (PO's) and Programme Specific Outcomes (PSO's)</b> (1/2/3 indicates strength of correlation) 3-Strong, 2-Medium, 1-Weak														
CO's	PO's												PSO's	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1	2	2	-	-	-	2	3	-	-	-	-	1	2	1
CO2	3	3	-	-	-	3	2	2	-	-	-	2	2	2
CO3	3	3	-	-	-	2	2	-	-	-	-	2	3	2
CO4	2	2	2	-	-	-	2	-	-	-	-	1	2	1
CO5	2	2	-	-	-	3	2	2	-	1	1	2	2	2



CM23856	RESOURCE RECOVERY FROM WASTE	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand sustainable development principles and mechanical methods for resource recovery from waste.				
2	learn composting, vermicomposting, and other biological techniques for waste valorization.				
3	develop bioconversion technologies for converting waste into useful bioenergy.				
4	gain knowledge of thermo-chemical processes used for energy recovery from solid waste.				
5	explore recycling technologies through case studies for various waste streams and materials.				
<b>UNIT I</b>	<b>MECHANICAL PROCESSING FOR MATERIAL RECYCLING</b>				<b>9</b>
Introduction to sustainable development and circular economy concepts – Systems for reduction, reuse, and recycling – Waste processing methods: segregation, hand sorting, waste storage – Conveyance and size reduction: shredding, pulping – Size separation by screens – Air classification – Magnetic separation – Eddy current separation – Sensor-based sorting for enhanced material recovery.					
<b>UNIT II</b>	<b>BIOLOGICAL PROCESSING FOR RESOURCE RECOVERY</b>				<b>9</b>
Biological waste treatment: aerobic and anaerobic routes – Factors affecting biodegradation – Composting systems: windrow, in-vessel, aerated static pile – Compost quality control parameters – Vermiculture and its applications – Constraints and potentials of large-scale composting in India – Community-level composting and decentralized treatment models.					
<b>UNIT III</b>	<b>BIO-CHEMICAL CONVERSION OF WASTE TO ENERGY</b>				<b>9</b>
Fundamentals of anaerobic digestion – Process parameters, control, and microbial kinetics – Methane generation, gas yield estimation – Anaerobic reactor configurations: single-stage, two-stage – High-rate digesters and commercial technologies – Biogas collection, upgrading, and storage – Integration of biogas with CHP (combined heat and power) units.					
<b>UNIT IV</b>	<b>THERMO-CHEMICAL CONVERSION OF WASTE TO ENERGY</b>				<b>9</b>
Principles and systems of energy recovery – Mass burn technologies, RDF systems – Thermal processes: incineration, gasification, pyrolysis, co-processing – Plasma arc technology – Energy balance and conversion efficiency – Emission control: flue gas cleaning, scrubbers, ESPs, bag filters – Environmental standards and monitoring.					
<b>UNIT V</b>	<b>CASE STUDIES ON WASTE RECYCLING</b>				<b>9</b>
Recycling processes for paper, glass, plastic, metals – Battery recycling: lead-acid and lithium-ion – End-of-Life Vehicle (ELV) recycling – E-waste: PCBs, components, and rare earth recovery – Waste oil refining – Solvent recovery systems – Drivers and barriers to recycling in India – Environmental and socio-economic impacts of recycling industries.					
				<b>TOTAL PERIODS</b>	<b>45</b>

COURSE OUTCOMES														
At the end of this course, students will be able to		<b>BT Mapped (Highest Level)</b>												
CO1	analyze existing and emerging technologies for material and energy recovery from waste.	Analyzing (K4)												
CO2	apply sustainable waste and resource management strategies to environmental systems.	Applying (K3)												
CO3	analyze solid waste as a secondary resource in a sustainable society.	Analyzing (K4)												
CO4	understand thermo-chemical energy recovery processes and emission control technologies.	Understanding (K2)												
CO5	apply material-specific recycling technologies for effective waste recovery.	Applying (K3)												
<b>TEXT BOOKS</b>														
1. Arne Veslind and Alan E Rimer, "Unit operations in Resource Recovery Engineering ", Prentice Hall Inc., London, 1981.														
2. Manser A G R, Keeling A A, "Practical handbook of processing and recycling on municipal waste", Pub CRC Lewis London, 1996. ISBN 1-56670-164														
<b>REFERENCES</b>														
1. Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein, Modern Composting Technologies JG Press October 2005														
2. Charles R Rhyner, Waste Management and Resource Recovery, Lewis Publishers, 1995.														
3. Manser A.G.R. and Keeling A.A, "Practical Handbook of Processing and Recycling of Municipal solid Wastes", Lewis Publishers, CRC Press, 1996.														
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CO3		3	3	3	2	2	2	2	2	2		3	2	2
CO4	2	2	2		3	3	2				2		2	2
CO5	2	2	2		1	3	2	2			2		2	



CM23857	MUNICIPAL SOLID WASTE MANAGEMENT	3	0	0	3
<b>COURSE OBJECTIVES</b>					
To enable the students to					
1	understand the sources, types, and generation patterns of municipal solid waste (MSW).				
2	learn on-site waste storage, segregation, and preliminary processing methods.				
3	acquire knowledge about MSW collection systems, routing, transfer, and field challenges.				
4	explore off-site processing and resource recovery options.				
5	understand landfill site selection, design, disposal methods, and environmental protection measures.				
<b>UNIT I</b>	<b>SOURCES AND TYPES</b>				<b>9</b>
Sources and classification of municipal solid wastes – Waste generation rates and influencing factors – Sampling and characterization techniques – Impacts of improper solid waste disposal – Public health and environmental concerns – Elements of MSW management – Socio-economic and financial aspects – Municipal Solid Waste (Management and Handling) Rules – Integrated solid waste management approach – Role of public awareness and NGOs.					
<b>UNIT II</b>	<b>ON-SITE STORAGE AND PROCESSING</b>				<b>9</b>
Methods of on-site waste storage – Impact of storage duration – Selection of materials for storage containers – Segregation practices – Public health implications of open storage – Indian case studies on waste segregation – Source reduction strategies – Concepts of Reduce, Reuse, and Recycle (3Rs) – Community-based waste minimization approaches.					
<b>UNIT III</b>	<b>COLLECTION AND TRANSFER</b>				<b>9</b>
Residential and commercial waste collection methods – Collection vehicles and equipment – Manpower requirements – Route optimization and logistics – Analysis of collection system performance – Design and operation of transfer stations – Criteria for location selection – Common field problems and resolution strategies – Collection models suitable for Indian urban and rural areas.					
<b>UNIT IV</b>	<b>OFF-SITE PROCESSING</b>				<b>9</b>
Goals of off-site processing – Physical processing techniques: shredding, compacting, separation – Equipment used – Resource recovery through composting and biomethanation – Anaerobic digestion – Thermal processing options: incineration, pyrolysis – Indian case studies highlighting successful technologies and challenges in implementation.					
<b>UNIT V</b>	<b>DISPOSAL</b>				<b>9</b>
Final disposal methods for MSW – Sanitary landfill design and operation – Site selection criteria – Landfill liners and covers – Leachate generation and treatment – Landfill gas control and utilization – Landfill bioreactors – Dumpsite remediation and rehabilitation – Best practices in post-closure monitoring and environmental impact reduction.					
<b>TOTAL PERIODS</b>					<b>45</b>



COURSE OUTCOMES		BT Mapped (Highest Level)
At the end of this course, students will be able to		
CO1	understand the sources, types, and impact of improper disposal of municipal solid waste.	Understanding (K2)
CO2	apply techniques for on-site storage, segregation, and source reduction.	Applying (K3)
CO3	analyze collection systems and transfer operations for municipal solid waste.	Analyzing (K4)
CO4	examine off-site processing options for material and energy recovery from MSW.	Analyzing (K4)
CO5	understand site selection and design of sanitary landfills including post-treatment systems.	Understanding (K2)

#### TEXT BOOKS

1. Tchobanoglous. G., Theisen, H. M., and Eliassen, R. Solid. Wastes: Engineering Principles and Management Issues. New York: McGraw Hill, 1977.
2. Vesilind, P.A. and Rimer, A.E., "Unit Operations in Resource Recovery Engineering", Prentice Hall, Inc., 1981.
3. Paul T Willams, "Waste Treatment and Disposal", John Wiley and Sons, 2005.

#### REFERENCES

1. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2016.
2. Bhide A.D. and Sundaresan, B.B. Solid Waste Management Collection, Processing and Disposal, 2001.
3. Manser A.G.R. and Keeling A.A, "Practical Handbook of Processing and Recycling of Municipal solid Wastes", Lewis Publishers, CRC Press, 1996.
4. George Tchobanoglous and Frank Kreith, Handbook of "Solid waste Management", McGraw Hill, New York, 2002

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CO4	3	2	2		2	3	2					3	2	2
CO5	2	2				3	3	2				2	2	

