M. Tech. (Chemical Engineering)
Department of Chemical Engineering
School of Energy Technology
Pandit Deendayal Energy University Gandhinagar

Pandit Deendayal Energy University Gandhinagar
School of Energy Technology
Department of Chemical Engineering

VISION

To impart quality education in an industry research driven modules to motivate the young chemical engineers for creating knowledge wealth to help generate employability following professional ethics and focus towards a sustainable environment and benefits to the society.

MISSION

- To facilitate the chemical engineering students with the state-of-the-art facilities with focus on skill development, creativity, innovation and enhancing leadership qualities.
- To nurture creative minds thru' mentoring, quality teaching & research for building a value based sustainable society.
- To work in unison with the national and international level academic and industrial partners by venturing into collaborations to tackle problems of bigger interest to society.
- To build an encouraging environment for the young faculties and staff by providing safe work culture, transparency, professional ethics and accountability that will empower them to lead the department in right spirit.
- To inculcate the culture of continuous learning among the faculties by encouraging them to participate in a professional development programs and envisage to address the social, economic and environmental problems.

Pandit Deendayal Energy University Gandhinagar
School of Energy Technology
Department of Chemical Engineering

PROGRAM EDUCATION OBJECTIVES (PEOs)

- Acquire the fundamental principles of science and chemical engineering with modern experimental and computational skills.
- Ability to handle problems of practical relevance of society while complying with economical, environmental, ethical, and safety factors.
- Demonstrate professional excellence, ethics, soft skills and leadership qualities.
- Graduates will be active members ready to serve the society locally and internationally.

PROGRAMME OUTCOMES (POs)

- **PO1 Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- **PO2 Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- **PO3 Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- **PO4 Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- **PO5 Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
- **PO6 The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent

responsibilities relevant to the professional engineering practice.

- **PO7 Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- **PO8 Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- **PO9 Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- **PO10 Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- **PO11 Project management and finance:** Demonstrate knowledge understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- **PO12 Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Semester I

SEMESTER-I (Subjects)				M.TECH._Sem.-I										
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/ wk	MS	ES	CE	LE	LE/Viva	
1		PCC	Advanced Chemical Reaction Engineering	3	0	0	3	3	25	50	25	-	-	100
2		PCC	Advanced Chemical Engineering Thermodynamics	3	1	0	4	4	25	50	25	-	-	100
3		PCC	Advanced Separation Technology	3	0	0	3	3	25	50	25	-	-	100
4		PCC	Advanced Transport Phenomena	3	0	0	3	3	25	50	25	-	-	100
5		PCC	Computer Aided Process Engineering	3	0	0	3	3	25	50	25	-	-	100
6		PCC	Advanced Chemical Engineering Research Lab	0	0	2	1	2	-	-	-	50	50	100
7		PCC	Computer Aided Process Engineering Lab	0	0	2	1	2	-	-	-	50	50	100
8		Project	Communication and Technical Writing Skills	2	0	0	2	2	25	50	25	-	-	100
			Total	**17**	**1**	**4**	**20**	**22**						

Semester II

COURSE STRUCTURE FOR M.TECH. CHEMICAL ENGINEERING FIRST YEAR SEM – II (w. e. f 2024-25)

SEMESTER-II (Subjects)				M.TECH._Sem.-II										
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					Total Marks
									Theory			Practical		
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	
1		PCC	Advanced Process Control	3	0	0	3	3	25	50	25			100
2		PCC	Software process Simulation Lab	0	0	2	1	2	-	-	-	50	50	100
3		PCE	Professional Core Elective_L - 1	3	0	0	3	3	25	50	25			100
4		PCE	Professional Core Elective_L - 2	3	0	0	3	3	25	50	25			100
5		PCE	Professional Core Elective_L - 3	3	0	0	3	3	25	50	25			100
6		PCE	Professional Core Elective_L - 4	3	0	0	3	3	25	50	25			100
7		Project	Research Methodology and IPR	2	0	0	2	2	25	50	25	-	-	100
8		Project	Seminar	-	-	-	1	-	-	-	-	50	50	100
			Total	**17**	**0**	**2**	**19**	**19**						

Elective Baskets

PCE1	**Elective Basket 1**
	Unit Operations and Processes in Environmental Engineering Theory
	Energy Conversion Device Engineering Theory
PCE2	**Elective Basket 2**
	Chemical Process Synthesis
	Renewable & Non-Renewable Energy
PCE3	**Elective Basket 3**
	Colloids and Interfacial Science and Engineering
	Carbon Sequestration and Clean Development Mechanism
PCE4	**Elective Basket 4**
	Materials Modeling and Simulation Techniques
	Nano-science and Energy Storage
	Computational Fluid Dynamics

Semester II

COURSE STRUCTURE FOR M.TECH. ENERGY AND ENVIRONMENTAL MANGEMENT FIRST YEAR SEM – II (w. e. f 2024-25)

SEMESTER-II (Subjects)				M.TECH._Sem.-II										
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	
1		PCC	Environmental Science and Engineering	3	0	0	3	3	25	50	25			100
2		PCC	Advanced Energy and Environmental Engineering Lab	0	0	2	1	2	-	-	-	50	50	100
3		PCE	Professional Core Elective_L - 1	3	0	0	3	3	25	50	25			100
4		PCE	Professional Core Elective_L - 2	3	0	0	3	3	25	50	25			100
5		PCE	Professional Core Elective_L - 3	3	0	0	3	3	25	50	25			100
6		PCE	Professional Core Elective_L - 4	3	0	0	3	3	25	50	25			100
7		Project	Research Methodology and IPR	2	0	0	2	2	25	50	25	-	-	100
8		Project	Seminar	-	-	-	1	-	-	-	-	50	50	100
			Total	**17**	**0**	**2**	**19**	**19**						

Elective Baskets

PCE1	**Elective Basket 1**
	Unit Operations and Processes in Environmental Engineering Theory
	Energy Conversion Device Engineering Theory
PCE2	**Elective Basket 2**
	Integrated Waste Management And Environmental Economics
	Renewable & Non-Renewable Energy
PCE3	**Elective Basket 3**
	Environmental Audit and Impact Assessment
	Life Cycle Assessment
PCE4	**Elective Basket 4**
	Energy and Environment Ecosystem
	Energy & Environment – Policy, Planning & Auditing

Semester III

COURSE STRUCTURE FOR M.TECH. CHEMICAL ENGINEERING SECOND YEAR SEM – III (w. e. f 2024-25)

SEMESTER-III (Subjects)				M.TECH. Sem. - III										
				Teaching Scheme					Exam Scheme					
Sr. No	Course Code	Category Code	Course Name						Theory			Practical		Total
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	Marks
1		Project	Project Phase - I	-	-	-	13	-	-	-	-	50	50	100
2		Project	Summer Internship /IEP (6 Week)	-	-	-	1	-	-	-	-	50	50	100
			Total	**0**	**0**	**0**	**14**	**-**						

Semester IV

COURSE STRUCTURE FOR M.TECH. CHEMICAL ENGINEERING SECOND YEAR SEM – IV (w. e. f 2024-25)

SEMESTER-IV (Subjects)				M.TECH. Sem. - IV										
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	
1		Project	Project Phase – II and Dissertatio n	-	-	-	16	-	-	-	-	50	50	100
			Total	**0**	**0**	**0**	**16**	**-**						

MS = Mid Semester, ES = End Semester; CE = Continuous Evaluation LW = Laboratory work; LE = Laboratory Exam

SYLLABUS

Semester I

SEMESTER-I (Subjects)				M.TECH. Sem.-I												
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	
1		PCC	Advanced Chemical Reaction Engineering	3	0	0	3	3	25	50	25	-	-	100
2		PCC	Advanced Chemical Engineering Thermodynamics	3	1	0	4	4	25	50	25	-	-	100
3		PCC	Advanced Separation Technology	3	0	0	3	3	25	50	25	-	-	100
4		PCC	Advanced Transport Phenomena	3	0	0	3	3	25	50	25	-	-	100
5		PCC	Computer Aided Process Engineering	3	0	0	3	3	25	50	25	-	-	100
6		PCC	Advanced Chemical Engineering Research Lab	0	0	2	1	2	-	-	-	50	50	100
7		PCC	Computer Aided Process Engineering Lab	0	0	2	1	2	-	-	-	50	50	100
8		Project	Communication and Technical Writing Skills	2	0	0	2	2	25	50	25	-	-	100
			Total	**17**	**1**	**4**	**20**	**22**						

					Advanced Chemical Reaction Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To develop understanding of non ideal reactor design.
2. Understand the concept of heterogeneous reaction system for reactor design.
3. Study Complex heterogeneous chemical reaction mechanisms and kinetics
4. Reactor design and stability, including consideration of multiple steady states using non isothermal energy balance

UNIT 1 Non ideal and non-isothermal reactor study 10 Hrs.

Review of isothermal and Adiabatic reactor design. Steady and unsteady state operations. Heat effects. Concept of multiple study state in CSTR. Homogeneous reactor design and analysis for non ideal reactors. Residence time distributions (RTD) studies. Single and multi parameter models for real reactor behavior, macro and micro mixing, segregated flow model

UNIT 2 Heterogeneous reactor studies 10 Hrs.

Heterogeneous reactors-gas-solid systems-Reviews of kinetics of gas-solid catalytic reactions with and without diffusion limitations. Solid catalysts and theirs application in reactor design for fixed and fluidized bed reactors.

UNIT 3 Study of gas liquid reactive systems 10 Hrs.

Design for non catalytic gas-liquid reactions. Review of kinetic regimes in reactor design, case studies. Gas-liquid systems, basic theories of mass transfer with chemical reaction. Reactor design for mechanically agitated
and bubble column reactors, selected case studies

UNIT 4 Development of Research Methodology 10 Hrs.

Bio Chemical Reaction and Bio reactors: Enzyme Fermentation, microbial fermentation, substrate-limiting and product limiting Microbial fermentation. Bio-reactor design.

Max: 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understanding and analyzing various Non-ideal reactors using RTD studies.
CO2: Conversion predictions and design by applying Non ideal models using zero, single and multiparameter models
CO3: Study and comparison of non-iosthermal reactors using overall energy balance equations.
CO4: Analyzing and evaluate the mechanisms of heterogeneous and multiphase reaction studies with various rate limiting steps.
CO5: Design of a reactor for homogeneous and heterogeneous reactions using modeling tools like MATLAB/ASPEN.
CO6: Understand biochemical reactions and with qualitative comparison with non-biological chemical reactions.

TEXT/REFERENCE BOOKS

1. Rawlings J.B. and Ekerd, J.G., Chemical Reactor Analysis and Design Fundamentals Nole. Hill 2002
2. Scot Foggler, H, Elements of Chemical Reaction Engg – PHI- 4th Edition- 2005.
3. Carberry, J.J. Chemical and Catalytic reaction engineering, Doven Publishers, 2001
4. O. Levenspiel,"Chemical Reaction Engineering" WilleyEastern,3rd Ed., 2000

					Advanced Chemical Engineering Thermodynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide a working knowledge of P-V-T behavior of pure fluids and mixtures.
2. To express a thermodynamic property in terms of measurable variables.
3. Develop an understanding of binary and multicomponent phase equilibria.

Unit 1: Volumetric Properties of Pure Fluids **12 hr**

General nature of PVT behavior of pure substances, Equation of states: Ideal gas law, Cubic equations of states – van der Waals equation of state, Redlich-Kwong equation of state, Soave-Redlich-Kwong equation of state, Peng-Robinson equation of state, generalized equations of state; the law of corresponding states, compressibility charts, Virial equation of state.

Unit 2: Thermodynamic Property Relations **13 hr**

Expressing various thermodynamic properties such as Internal energy, enthalpy, Helmholtz free energy, Gibbs free energy, etc., in terms of measurable thermodynamic properties, Gibbs equations, Maxwell's equations, and application of property relationships, Residual properties, Residual properties from equations of state, Generalized correlations for residual properties, Vapor pressure, Antoine equation.

Unit 3: The Framework of Solution Thermodynamics **13 hr**

The chemical potential and equilibrium, partial properties, fugacity and fugacity coefficients of pure species and mixtures, and Generalized correlations for fugacity coefficients. The ideal solution model and excess properties. Raoult's law and Henry's law, Modified Raoult's law, Bubble point and Dew point calculations.

Unit 4: Thermodynamic formulation for Vapor-Liquid Equilibrium **12 hr**

Excess Gibbs Energy and activity coefficient, The Gamma/Phi formulation of VLE, Correlations for liquid-phase activity coefficients: The Redlich/Kister expansion, Margules equations, The van Laar equation, fitting activity coefficient model to VLE data, VLE from cubic equations of state.

Max 50 hr

COURSE OUTCOMES

CO1: Highlighting various equations of state to study the real fluid behavior.
CO2: Relating various thermodynamic properties to predict them in terms of measurable properties.
CO3: Apply equations of state to calculate thermodynamic properties of pure species.
CO4: Analyzing the liquid and vapor phase equilibrium with bubble and dew point calculations.
CO5: Evaluate the pure substance and mixture properties using generalized correlation data.
CO6: Composing the activity coefficient models using the VLE data.

TEXT/REFERENCE BOOKS

1. J. M. Smith, H. C. Van Ness, M. M. Abbott, M. T. Swihart: Introduction To Chemical Engineering Thermodynamics, 9th Edition, McGraw-Hill Education, New York.
2. B. E. Poling, J. M. Prausnitz, J. P. O'Connell - The properties of gases and liquids, 5th edition, McGraw-Hill Professional.
3. J. M. Prausnitz, R. N. Lichtenthaler, E. G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd edition, Prentice Hall PTR.

					Advanced Separation Technology					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To gain knowledge of membrane separation processes.
2. To gain knowledge of adsorption and ion exchange processes and study adsorption equilibrium and isotherms for different type of systems.
3. To gain knowledge of ionic liquid as separation media.

UNIT 1 Introduction **2 Hrs.**

Fundamentals of separation processes, Separation factor, various separation processes.

UNIT 2 Membrane Separation **13 Hrs.**

Membrane separation processes, materials, module design and characteristics, Pressure driven membrane processes, ion exchange techniques and operation, Gas separation, mixing model for gas separation, cross flow model, single stage membrane separation, multistage membrane separation, differential permeation with point permeate withdrawal.

UNIT 3 Adsorption **13 Hrs.**

Introduction, Adsorption isotherms. Single-stage and multi-stage, Cross-current and counter current operations, Equilibrium and operating lines, Liquid-solid agitated vessel, Packed continuous contactor, Rate equations for non- porous and porous adsorbents, Non-isothermal operation, pressure-swing adsorption, Principles of ion exchange, Analogy between adsorption and ion exchange.

UNIT 4 Ionic Liquid **12 Hrs**.

Room Temperature Ionic liquids (RTIL), Physico-chemical properties of RTIL, reactivity, solvating power, Ionic Liquids as advanced materials in analytical separations, absorption/adsorption, membrane separations; Applications of Ionic Liquids in biotechnology and bio-refining, Chemicals and petrochemicals, CO_2- separation, Environmental remediation, Waste treatment.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 : Define the principle of separation processes.

CO2 : Explain the knowledge of separation processes.

CO3 : Identify the separation process in the given condition.

CO4 : Analyze the problems related to separation processes.

CO5 : Determine the separation under desired condition.

CO6 : Design module for separation processes like membrane, adsorption.

TEXT/REFERENCE BOOKS

1. R. Rautenbach, and R. Albercht, Membrane Processes, John Wiley & Sons,(1994)
2. Simon Judd*.,* Principles and Applications of Membrane Bioreactors for Water and Wastewater Treatment, Elsevier, 9780080465104, 2011
3. Scott T. Handy, Application of Ionic liquids in Science and Technology, InTech Publication, ISBN 978-953-307-605-8, 2011
4. Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk, Chromatography: Basic Principles, Sample Preparations and Related Methods, Wiley-VCH , 2014, ISBN: 978-3-527-33620-3

					Advanced Transport Phenomena					
Teaching Scheme					Examination Scheme					
					Theory			Practical		
L	T	P	C	h/Week	MS	ES	IA	LW	LE/Viva	Total Marks
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES:

1. To make understand the basic and fundamental concepts of various transport processes in chemical engineering
2. To analyze various transport processes with understanding of solution approximation methods and their restrictions
3. Application of different correlations used in momentum, heat and mass transfer problems to solve chemical engineering problems

UNIT 1 Vectors And Tensors **7 Hrs.**

Introduction: Vectors And Tensors, Conservation Principles, Eulerian &Lagrangian Observers. Equations Of Change. Integral and Differential Forms, Newtonian &Non-Newtonian Fluids

UNIT 2 Momentum Transport **14 Hrs.**

Momentum Transport Mechanisms, Laminar flow between plate's, velocity profiles, shear stress & pressure drop in steady flow, Time smoothed equations for turbulent flow.Boundary layers flow past bodies

UNIT 3 Energy Transport **11 Hrs.**

Energy Transport Mechanisms, Laminar flow temperature profiles - the Graetz problem.Steady and unsteady free convection, Boundary layers, Time smoothed equations and analogy with turbulent flow momentum transfer

UNIT 4 Mass transport **10 Hrs.**

Mass transport mechanism: Diffusion; Constitutive Laws: Diffusion Flux Laws/ Coefficients, general constraints, Laminar flow concentration profiles. Steady and unsteady convective mass transfer, Diffusion in gases and liquids.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Recall the knowledge in vector calculus and numerical methods and define the momentum, energy and mass fluxes in various coordinate system and their individual components

CO2: Explain the mechanisms for momentum transfer for various flow systems and show how these mechanisms influence heat and mass transfer.

CO3: Application of shell balance methods and develop modelling thoughts to solve fundamental transport equations including non-steady state equations of momentum, energy and mass transport in terms of flux quantities>

CO4: Analyze and simplify various equations of change developed in shell balance equations of momentum, energy and mass transport

CO5:Recommend boundary conditions and mathematical techniques to solve equations of change involving momentum, energy and mass transport

CO6 :Formulate the dimensionless groups and develop correlations to analyze and solve various transport problems

TEXT/REFERENCE BOOKS

1. R. B. Bird, W. E Stewart, and E. N. Lightfoot, Transport Phenomena, Edition-2 John Wiley, 2007>
2. J. Welty, G. L. Rorrer, D. G. Foster, 'Fundamentals of Momentum, Heat, and Mass Transfer', Revised 6th Edition, Wiley, 2014 >
3. J R Backhurst, J H Harker, J.F. Richardson, and J.M. Coulson, 'Chemical Engineering Volume 1: Fluid Flow, Heat Transfer and Mass Transfer', 6th Edition, Butterworth-Heinemann, 1999 >

					Computer Aided Process Engineering					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To learn about the usage and role of computer tools for integrated process plant engineering.
2. To provide the students with a clear understanding of what is process simulation & process optimization using commercial software (Aspen/Hysis).
3. To solve practical problems commonly encountered in process engineering.
4. To learn how the use of computer aided tools will play an important role in life

UNIT 1 Integrated Chemical-Process Design: CAPE Perspectives **10 Hrs.**

Introduction to Process Plant Design and Simulation: hierarchy levels, depth, and basic steps; components in a simulation package. CAPE problem formulation, Steady-state sequential modular and equation-oriented approach: decomposition of networks; Tearing algorithms, Sensitivity analyses, Design specifications.

UNIT 2 Databases and modelling in Thermophysical properties **10 Hrs**.

Thermodynamic property estimation, methods and models in process simulations: Property data requirements and input, Physical property analysis, EOS and activity coefficient models, Data regression and estimation of parameters. Stream and block parameters, recycle convergence algorithms, Dynamic simulation.

UNIT 3 Equipment and Process Design **9 Hrs.**

Separation equipment, distillation and absorption design, Azeotropic distillation using pressure swing, Heat exchangers: design, rating and simulation, ideal and non-ideal reactors, Pressure changers, case studies, Ammonia process, petroleum refining process, etc.

UNIT 4 Process Energy analysis and Economic evaluation **11 Hrs.**

Process Energy integration, identifying energy and greenhouse gas reduction in the design process, Heat Exchanger Network Diagram and Composite Curves. Pinch analysis. Process Economic Analysis: Costing Options and Utilities, Mapping Unit Operations, Sizing and Evaluating for CAPEX and OPEX, case studies

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 : Understand, create, select, and Describe computer tools for chemical process Engineering>

CO2 : Examine and explain thermodynamic properties estimation using computer tools>

CO3 : apply stream and block parameters to a chemical unit operation for computer aided simulation>

CO4 : solve process design and simulation calculations of various processes using Aspen software with cost>

CO5 : determine process simulation with economic analysis using Aspen software >

CO6 : Outline process energy analysis and construct Heat exchanger networks.

TEXT/REFERENCE BOOKS

1. Chemical Process Design and Simulation: Aspen Plus and Aspen Hysys Applications by Juma Haydary, 2019 John Wiley & Sons, Inc.
2. Computer Aided Process & Product Engineering, Dr. Luis Puigjaner, 2006, WILEY-VCH Verlag GmbH & Co
3. Aspen documentation and manuals, Aspen Tech

					Advanced Chemical Engineering Research Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	00	00	00	50	50	100

COURSE OBJECTIVES

1. To understand various experiment and methods related with Chemical Engineering.
2. To understand the limitations of the various synthesis techniques.
3. To understand various mathematical software related with Chemical Engineering.
4. To understand the use of Matlab, Polymath and GAMS.

LIST OF EXPERIMENTS:

1. To study the FTIR Techniques.
2. To study the gas separation techniques using GC-MS.
3. Synthesize copper oxide nanoparticles by sol-gel method and determine the average size of nanoparticles using Particle Size Analyzer.
4. To study Ball milling route for making nanoparticles and particle size distribution estimation.
5. To study Microwave assisted synthesis of ZnO nanoparticles.
6. To Synthesis and Characterization of carbon nanotubes by cracking of gas mixture
7. Fabricate silver nanoparticles embedded in silica glass by ion exchange method and study surface Plasmon resonance using UV-visible spectroscopy.
8. Fabricate copper nanoparticles embedded in silica glass by ion exchange method and determine the size of nanoparticles using optical absorption spectroscopy.
9. Fabrication of suitable structures on thin films for device applications.
10. To investigate refluxing and distillation techniques for synthesis of II-VI ceramic nanostructures.
11. To study solvothermal synthesis method of nanoparticles

COURSE OUTCOMES: On completion of the course, student will be able to

CO1: Understand FTIR, GC-MS and other instrument techniques.
CO2: Examine and explain the average size of nanoparticles using Particle Size Analyzer

CO3: Apply knowledge in Ball milling and Microwave assisted synthesis
CO4: Demonstrate Synthesis and Characterization of materials.
CO5: Analyse the materials.
CO6: Explain the different synthesis methods for materials.

					Computer Aided Process Engineering Lab					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
0	**0**	**2**	**1**	**2**				**50**	**50**	**100**

COURSE OBJECTIVES

1. To learn and apply appropriate modern software tool (Aspen plus/ hysis simulator) including modelling to complex chemical engineering processes with an understanding of the limitations.
2. Identify the components of physical and thermodynamic property models and Learn software aspects of rapid solution.
3. Learn application and solve chemical process flow sheeting problems more quickly, efficiently and successfully using computer aided tools
4. Learn concepts of process integration and to solve heat exchanger network problems.

Process Simulation Exercises Using Aspen Plus:

1. Construct a simulation sheet with process blocks and streams
2. Physical property estimation, Critical properties, ΔH, ΔG etc.
3. Thermodynamic property estimation and analysis, T-xy, P-xy and xy diagrams
4. Data Regression, Vapour-liquid equilibrium data, Flash separation, dew point, bubble point,
5. Mass and Energy balances calculations in Aspen platform
6. heat exchangers, design, rating, calculation with TEMA specification
7. Thermal analysis, simulation of heat exchanger
8. Process simulations of reactors
9. Design and Simulation of distillation and absorption column,
10. Azeotropic distillation using pressure swing distillation
11. Costing and economic analysis; (case study: ammonia production process)
    - Open loop process
    - Closed loop process
12. Dynamic simulation of a reactor
13. Solving Heat exchanger network

COURSE OUTCOMES: On completion of the course, student will be able to
CO1 - Estimate, physical and thermodynamic properties of new organic compounds.
CO2 –Estimate and list mass and energy balance of a process flow sheet using Aspen plus.
CO3 –Construct thermodynamic phase diagrams using activity coefficient and Equation of state models using computer simulation.
CO4 - determine flow sheeting solution by using design specification and sensitivity analysis approach. CO5 - solve process design and simulation calculations of various unit operations using Aspen software.
CO6 – demonstrate Heat exchanger networks using Aspen Process simulators.

TEXT/REFERENCE BOOKS

1. Chemical Process design and Simulation by Juma Haydary, 2019 John Wiley &sons, Inc
2. Aspen Plus: All Manuals and PDF documents

Course Code: XXXXXX					Scientific Writing and Publication Ethics					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs./Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
2	**0**	**0**	**2**	**2**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To comprehend the significance of scientific writing and to understand of the basic structure of a scientific paper.
2. To get familiarize with the process of selecting appropriate target journals and conferences.
3. To cultivate an awareness of publication ethics within the realm of scientific writing.
4. To get acquainted with the knowledge and tools necessary to identify, understand, and avoid plagiarism in scientific writing

UNIT-1: Introduction to Scientific Writing **07 Hrs.**
Importance of scientific writing in engineering, understanding the structure and components of a scientific paper, research paper writing style, referencing style

UNIT 2: Selecting Target Journals and Conferences **07 Hrs.**
Types of journals and conferences in engineering, open access journals, journal impact factors, conference rankings, manuscript submission process, responding to reviewer comments

UNIT 3: Publication Ethics **07 Hrs.**
Introduction and importance, publication misconduct, violation of publication ethics, falsification and/or fabrication of data, understanding of copyright form, collaboration issues (authorship), conflicts of interest issues, Committee on Publication Ethics (COPE)

UNIT 4: Avoiding Plagiarism **07 Hrs.**
Plagiarism – definition, reasons for plagiarism, types of plagiarism, avoiding plagiarism

TOTAL **28 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 - describe the importance of scientific writing in engineering and identifying its role in knowledge dissemination and academic integrity
CO2 - understand the structure and components of a scientific paper
CO3 - e**valuate and select suitable journals and conferences to submit their research work**
CO4 - understand publication ethics
CO5 - define plagiarism, identify its different types and reasons, and apply techniques to avoid plagiarism
CO6 - **analyze and respond to reviewer comments for their research work**

TEXT/REFERENCE BOOKS

1. Getting It Published: A Guide for Scholars and Anyone Else Serious about Serious Books by William Germano
2. Publish and Flourish: Become a Prolific Scholar by Tara Gray
3. Adil E. Shamoo, and David B. Resnik, Responsible Conduct of Research, Oxford University Press
4. Gary Comstock, Research Ethics: A Philosophical Guide to the Responsible Conduct of Research, Cambridge University Press
5. Tony Mayer, and Nicholas H. Steneck, Promoting Research Integrity in a Global Environment, World Scientific Publishing
6. Ethical Issues in Engineering Research, Publication, and Practice by Caroline Whitbeck

Semester II

COURSE STRUCTURE FOR M.TECH. CHEMICAL ENGINEERING FIRST YEAR SEM – II (w. e. f 2024-25)

SEMESTER-II (Subjects)				M.TECH._Sem.-II										
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					
									Theory			Practical		Total
				L	T	P	C	Hrs/wk						Marks
									MS	ES	CE	LE	LE/Viva	
1		PCC	Advanced Process Control	3	0	0	3	3	25	50	25			100
2		PCC	Software process Simulation Lab	0	0	2	1	2	-	-	-	50	50	100
3		PCE	Professional Core Elective_L - 1	3	0	0	3	3	25	50	25			100
4		PCE	Professional Core Elective_L - 2	3	0	0	3	3	25	50	25			100
5		PCE	Professional Core Elective_L - 3	3	0	0	3	3	25	50	25			100
6		PCE	Professional Core Elective_L - 4	3	0	0	3	3	25	50	25			100
7		Project	Research Methodology and IPR	2	0	0	2	2	25	50	25	-	-	100
8		Project	Seminar	-	-	-	1	-	-	-	-	50	50	100
			Total	**17**	**0**	**2**	**19**	**19**						

Elective Baskets

PCE1	**Elective Basket 1**
	Unit Operations and Processes in Environmental Engineering Theory
	Energy Conversion Device Engineering Theory
PCE2	**Elective Basket 2**
	Chemical Process Synthesis
	Renewable & Non-Renewable Energy
PCE3	**Elective Basket 3**
	Colloids and Interfacial Science and Engineering
	Carbon Sequestration and Clean Development Mechanism
PCE4	**Elective Basket 4**
	Materials Modeling and Simulation Techniques
	Nano-science and Energy Storage
	Computational Fluid Dynamics

					Advanced Process Control					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To revisit SISO processes and their control using the Transfer function approach.
2. To develop an understanding of CT and DT state-space models for MIMO processes.
3. To understand the controllability of MIMO processes and the development of various control mechanisms for them.

UNIT I: SISO SYSTEMS, TRANSFER FUNCTION APPROACH 10 Hrs.

SISO systems: Laplace transformation, transfer function models; the transient response of first and second-order processes for impulse, step, sinusoidal, ramp inputs; P, PI, and PID controllers; frequency response; stability analysis, controller tuning methods.

UNIT II: MIMO SYSTEMS 10 Hrs.

MIMO systems: continuous-time (CT) state-space models; CT transfer function matrix models; introduction to computer-controlled systems, simple discrete-time (DT) systems; sampling, Shanon-Nyquist sampling theorem, and analog-to-digital transformation; zero-order-hold and digital-to-analog transformations, DT state-space model, Z-transformation, Z - transfer function models, inter-conversion of models.

UNIT III: APPLICATION OF LINEAR ALGEBRA IN CONTROLLABILITY AND STABILITY 10 Hrs.

Linear Algebra: row, column space of a matrix, linear independence, the rank of a matrix, Eigen-value and Eigen-vector analysis, diagonalization of a matrix, exponential of a matrix; Controllability of state-space models, controllability matrix and condition for a controllable system, and Popov-Belevitch-Hautus (PBH) test; stability of various CT and DT models.

UNIT IV: CONTROLLERS FOR MIMO PROCESSES 10 Hrs.

Relative-gain-array, Dynamic-decoupler design; Full-state feedback controller design using pole-placement method (CT&DT both); Linear quadratic regulator, FIR and FSR models, prediction and control horizon, introduction to model predictive control.

TOTAL HOURS: 40 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to:

CO1 : Highlighting the basics of process control using SISO systems.
CO2 : Understanding various representations of process control systems.
CO3 : Apply linear algebra and other mathematical techniques to find the response of MIMO process.
CO4 : Analyze the system's controllability and stability.
CO5 : Evaluate the updated states using the convolution method in discrete models.
CO6 : Compose FSFB, dynamic-decoupler, and MPC-based controllers.

TEXT/REFERENCE BOOKS

1. G. Stephanopoulos, Chemical Process Control, Prentice-Hall India Learning Pvt.Ltd., 2008.
2. K.J. Åström, B. Wittenmark, Computer-Controlled System – Theory and Design, Prentice-Hall, 1996.
3. A. K. Tangirala, Principles of System Identification: Theory and Practice, CRC Press, 2014.

					Software process Simulation Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To develop transfer function and state-space models for SISO and MIMO processes using a programming tool.
2. To design controllers for the processes using PID design, pole-placement method, and LQR, etc.
3. To use various system identification models and find out the process dynamics.

LIST OF EXPERIMENTS

1 To Create system models such as transfer function, and state-space (CT and DT both) models.
2 To find time and frequency domain responses.
3 To design a PID controller and lead-lag design.
4 To design a controller using the Pole-placement method.
5 To design a linear quadratic regulator (LQR) and a linear quadratic Gaussian (LQG).
6 Analyzing the control of time-delay systems.
7 System identification using Linear ARX models.
8 System identification using the prediction-error method.
9 Prefiltering the data for identification.
10 To analyze the excitation for parameter estimation.

COURSE OUTCOMES

On completion of the course, students will be able to:

CO1 : Defining transfer function and state-space models.
CO2 : Understanding the PID controllers by varying various parameters of the controller equation.
CO3 : Apply various identification models to find the system's dynamics equation.
CO4 : Analyze the excitations to properly estimate the parameters of a process.
CO5 : Evaluate the transient response of a few processes for impulse and step inputs using a programming tool.
CO6 : Build different controllers using pole-placement, LQR, and LQG methods.

TEXT/REFERENCE BOOKS

1. G. Stephanopoulos, Chemical Process Control, Prentice-Hall India Learning Pvt.Ltd., 2008.
2. A. K. Tangirala, Principles of System Identification: Theory and Practice, CRC Press, 2014.
3. F. Bagge Carlson, M. Fält, A. Heimerson, and O. Troeng, ControlSystems.jl: A Control Toolbox in Julia. In 2021 60th IEEE Conference on Decision and Control (CDC) IEEE Press, 2021.

					Unit Operations and Processes in Environmental Engineering					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					MS	**ES**	**IA**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

1. To understand the chemical engineering approaches in environmental engineering.
2. To identify and understand design approach for water and waste water treatment.
3. To understand and identify preliminary unit operations in water and wastewater treatment.
4. To understand and identify biological treatment of wastewater treatment.

UNIT 1 – INTRODUCTION **10 Hrs.**

Water demand, Wastewater generation, Water & wastewater quality criteria, Water & wastewater treatment system overview, Mass balances, Flow models & reactors.

UNIT 2 – DISSOLVED OXYGEN BALANCE AND MODEL **9 Hrs.**

Dissolved oxygen balance, Dissolved oxygen model, Oxygen sag curve, Oxygen transfer and mixing, Estimation of lumped oxygen transfer concentration, Aeration & Agitation for environmental processes.

UNIT 3 – PRELIMINARY & PRIMARY UNIT OPERATIONS AND PROCESSES **9 Hrs.**

Equalization, Sedimentation, Coagulation and Flocculation, Filtration, Desalination, Leaching.

UNIT 4 – BIOLOGICAL TREATMENT OF WASTES **12Hrs.**

Batch& continuous processes: Mixed cultures, Activated sludge process, Trickling filters and Rotary biological contactors, Stabilization ponds and Aerated lagoons, Anaerobic digestion, Aerobic digestion, Solids Handling: Land treatment of municipal wastewater and sludges, Sludge incineration, Sludge disposal.

Max:- 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 : Define the basic knowledge of unit operations and processes in environmental engineering.
CO2: Classify flow models & reactors implicated in environmental engineering.
CO3 : Apply knowledge in mass balances, oxygen sag curve and lumped oxygen transfer concentration.
CO4 :Examine water and wastewater quantity and quality.
CO5 : Explain dissolved oxygen concept, preliminary, primary and biological treatment processes.
CO6 : Design and discuss the units involved in the treatment processes and operations of wastes.

TEXT/REFERENCE BOOKS

1.Tom D. Reynolds, Paul Richards, Unit Operations and Processes in Environmental Engineering, CL Engineering, second edition, 1995.
2.R. Noyes, Unit Operations in Environmental Engineering, first edition, Noyes Publications, 1994.

<Course_Code>					Energy Conversion Device Engineering					
Teaching Scheme					**Examination Scheme**					
L	**T**	**P**	**C**	**Hrs/Week**	**Theory**			**Practical**		**Total Marks**
					IA	**MSE**	**ESE**	**LW**	**LE/Viva**	
3	**0**	**0**	**3**	**3**	**25**	**25**	**50**	**--**	**--**	**100**

COURSE OBJECTIVES

1. Know the basic scientific processes behind various energy conversion devices, namely Batteries, Fuel cells, Photo(electro)chemical Hydrogen generators, and Solar cells.
2. Understand the fabrication, working, and disposal of these energy conversion devices
3. Build the Engineering perspectives on efficient energy generation using these devices.
4. Design methods for networking, stacking, and multiplexing the devices for optimum usage in process plants

UNIT 1 Introduction and Basic Principles **12 Hrs.**

Electrochemical Cells, Characteristics of Electrochemical Reactions, Importance of Electrochemical Systems, Faraday's Law, Cell Potentials, Nernst equation and variants, Standard Potentials, Use of the Cell Potential, Pourbaix Diagrams, Reference Electrodes, Impact of Potential on Reaction Rate, Butler–Volmer equation, the influence of Mass Transfer on the Reaction Rate, Kinetics in full cells, various efficiency measurements in the Electrochemical Systems, Electric and Hybrid Systems, Power Demand in Vehicles, Hybrid Vehicle Architectures

UNIT 2 Battery Fundamentals **09 Hrs.**

Components of a Cell, classification of Batteries and Cell chemistries, Theoretical Capacity and the State of Charge, Cell Characteristics and Electrochemical Performance, Ragone Plots, Efficiency of Secondary Cells, Charge Retention and Self-Discharge, Capacity Fade in Secondary Cells, Redox-Flow Batteries, Scaling of Cells to Adjust Capacity, Thermal management, Mechanical Considerations, Battery Electrical Vehicles, Batteries for Full-Hybrid Electric Vehicles

UNIT 3 Fuel-Cell Fundamentals **09 Hrs.**

Types and components of Fuel Cells, Current-Voltage Characteristics and Polarizations, Effect of Operating Conditions and Maximum Power, Electrode Structure, Proton-Exchange Membrane Fuel Cells, Solid Oxide Fuel Cells, Basic Stack Design Concepts, Cell Stack Configurations, Utilization of Oxidant and Fuel, Flow-Field Design, Water and Thermal Management, Structural–Mechanical Considerations, Fuel-cell Hybrid Systems for Vehicles

UNIT 4 Photoelectrochemical Cells and Electrochemical Double-Layer Capacitors **10 Hrs.**

Semiconductor Basics, Energy Scales, Semiconductor–Electrolyte Interface, Current Flow in the Dark, Light Absorption, Photoelectrochemical Effects, Photo-Electrochemical Cells, Electrical Double-Layer Capacitance, Current-Voltage Relationship for Capacitors, Electrode structure, Impedance Analysis, Full Cell analysis, Power and Energy Capabilities, Cell Design, Practical Operation, and Electrochemical Capacitor Performance, Pseudo-Capacitance, Applications in Hybrid and Electrical Vehicles

Max. 40 Hrs.

COURSE OUTCOMES

Upon completion of the course, the student will be able to

CO1 - Define the basics of electrochemical energy conversion and its use in vehicular aspects.

CO2 - Demonstrate the testing procedures and characterisation of energy conversion devices.

CO3 - Apply the energy conversion principles to augment the engineering of the device.

CO4 - Evaluate the energy conversion devices' performances in vehicles based on the lab tests.

CO5 - Analyse practical application challenges in energy conversion devices.

CO6 - Design a networked system of energy conversion devices to meet the vehicular power demand.

TEXT/REFERENCE BOOKS

1. Thomas F. Fuller and John N. Harb, Electrochemical Engineering (1st edition, 2018), Wiley.
2. Serguei N. Lvov, Electrochemical Science and Engineering (1st edition, 2015) CRC Press.
3. Richard C. Alkire, Philip N. Bartlett, and Marc T. Koper (Eds.), Advances in Electrochemical Science and Engineering (Vol. 18, 2019): Electrochemical Engineering: The Path from Discovery to Product,Wiley-VCH.
4. A.J. Bard, M. Stratmann, D.D. Macdonald, and P. Schmuki, Encyclopaedia of Electrochemistry (Vol. 5, 2007): Electrochemical Engineering, Wiley-VCH.

Pandit Deendayal Energy University School of Energy Technology

					Chemical Process Synthesis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the basics of chemical process development and approach to process design.
2. To know about the type of reactor and its performance.
3. Learn to understand choice of separator and distillation sequencing.
4. To understand the various safety and health considerations.

Unit I: Introduction to Chemical Process Design **9 hrs**

Introduction, approach to process development, development of new process, different considerations, development of particular process, overall process design, hierarchy of process design, onion model, approach to process design.

Unit II: Choice of Reactor **10 hrs**

Reaction path, types of reaction systems, reactor performance, idealized reactor models, reactor concentration, temperature, pressure, phase, catalyst.

Unit III: Choice of Separator and distillation sequencing **12 hrs**

Separation of heterogeneous mixtures, separations of homogeneous mixtures, distillation, azeotropic distillation, absorption, evaporation, drying etc. Distillation sequencing using simple columns, heat integration of sequences of simple distillation columns, distillation sequencing using thermal coupling.

Unit IV: Safety and Health considerations **9 hrs**

Fire, explosion, toxic release, intensification of hazardous materials, attenuation of hazardous materials, quantitative measures of inherent safety, overall safety and health considerations.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1: List out various new chemical process developments.
CO2: Outline the hierarchical approach to conceptual process design.
CO3: Apply the concept for choice of reactor, reaction systems and reactor performance.
CO4: Categorize the various separation process for homogeneous and heterogeneous mixtures
CO5: Recommend distillation sequencing using simple columns, heat integration and thermal coupling. CO6: Adopt various quantitative measures of inherent safety, overall safety and healthconsiderations.

TEXT/REFERENCE BOOKS

1. Chemical process design- Robin Smith, Wiley.
2. Conceptual design of chemical process-James Douglas, McGraw Hill Book Company.
3. Unit process in organic synthesis – P.H. Groggins, Tata McGraw Hill Publishing Company Ltd.
4. Dryden's Outline of Chemical Engineering, Rao and M Gopala, East-WestPress.

Course Code					Renewable and Non-Renewable Energy					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To impart knowledge on classification of energy sources and their environmental aspects
2. Learn the present energy scenario and concept of sustainable energy
3. Explain the concept of various forms of renewable energy and discuss the scientific principles underpinning the sustainable conversion of energy
4. To impart problem oriented in depth knowledge of renewable energy sources

UNIT 1:ENERGY CLASSIFICATION AND NON-RENEWABLE ENERGY **10 Hrs**

Global & National energy scenarios, Interrelationship between energy and environment, Energy classification- Primary & Secondary energy, commercial & non-commercial energy, non-renewable & renewable energy, primary energy resources, commercial energy production, energy conservation and its importance Non-Renewable energy and their impact on the ecology, Key factors in the exploitation, production and use. Forms & characteristics of renewable energy sources.

UNIT 2:SOLAR ENERGY **10 Hrs**

Principles of solar radiation - Origin, nature and availability of solar radiation, estimation of solar radiation, solar geometry, and heat transfer considerations relevant to solar energy.Solar energy collection - Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis. Solar energy storage and applications - Sensible, latent heat and stratified storage, solar ponds. Solar Applications- solar heating/cooling technique, solar distillation and drying, Photovoltaic energy conversion, p-n junction, solar cells, PV systems, Stand- alone, Grid connected solar power

UNIT 3: WIND, HYDRO AND GEOTHERMAL ENERGY **10 Hrs**

Principle of wind energy conversion, basic components of wind energy conversion systems - Lift and Drag– Effect of density, frequency variances, angle of attack, and wind speed - design considerations of horizontal and vertical axis wind machines - analysis of aerodynamic forces acting on wind turbine blades and estimation of power output - wind data and site selection considerations. Principles of working, lay out, Site selection classification and arrangement of hydroelectric plants, run off size of plant and choice of units, operation and maintenance, hydro systems, and interconnected systems. Geothermal Energy - nature of geothermal energy, resources like hydrothermal, geo-pressured hot dry rock, magma. Advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India.

UNIT 4: OTHER RENEWABLE ENERGY SOURCES **12 Hrs**

Biogas - Principles of Bio-Conversion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, Biomass gasification - Biomass conversion technologies, Constructional details of gasifier, Biofuels
- Introduction and perspective of biofuels, biofuel production and applications, environmental impact of biofuel, Biofuel operated I.C. Engine operation and economic aspects. Energy from Ocean – Basic cycles of Ocean Thermal Energy Conversion, basic principle of tidal power, wave energy conversion devices. Fuel Cells - Introduction, Design principle and operation of fuel cell and its types, conversion efficiency of fuel cell, application. Hydrogen Energy - Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, hydrogen as alternative fuel for vehicles.

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define different forms of energy and list advantages and disadvantages of different sources of energy

CO2: Understand the principles of solar radiation, its availability at various locations and extend the knowledge to different applications

CO3: Develop knowledge to harness energy from different sources for various applications like heating, cooling, water distillation, electricity etc. and model their performance.

CO4: Analyse and compare different energy sources and their impacts

CO5: Interpret the suitability and determine the best possible energy resource for a particular location

CO6: Design and develop innovative methods to harness energy and propose sustainable solutions.

TEXT/REFERENCE BOOKS

1. Sukhatme, S.P. and Nayak, J.K., 2017. Solar energy. McGraw-Hill Education
2. Duffie, J.A., Beckman, W.A. and Worek, W.M., 2013. Solar engineering of thermal processes (Vol. 3). New York: Wiley
3. Kothari, D.P., Singal, K.C. and Ranjan, R., 2011. Renewable energy sources and emerging technologies. PHI Learning Pvt. Ltd

					Colloids and Interfacial Science and Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understanding of nomenclature, concepts and tools of colloid and interface science and engineering.
2. A clear understanding of differences between the surface and bulk dominated regimes and behavior.

UNIT 1 Surface Tension, Adhesion and capillarity: 12 Hrs.

Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; Apolar (van der Waals) and polar (acid-base) components of interfacial tensions Young-Laplace equation of capillarity; examples of equilibrium surfaces; multiplicity, etc.; Stability of equilibrium solutions; Contact angle and Young's equation; Determination of apolar (van der Waals) and acid-base components of surface/interfacial tensions; Free energies of adhesion Kinetics of capillary flows

UNIT 2 Intermolecular and interfacial forces 10 Hrs.

van der Waals, Electrostatic double layer, Maxwell-Boltzmann equation, Debye screening length, Acid-base interactions including hydrophobic attraction and hydration pressure.

UNIT 3 Mesoscale & Surface thermodynamics 8 Hrs.

Gibbs treatment of interfaces; concept of excess concentration; variation of interfacial tensions with surfactant concentration.

UNIT 4 Stability of colloidal dispersions 10 Hrs.

DLVO and DLVO like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement

Max: 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Highlighting various applications of Colloid and Interface Science. CO2 - Categorizing various types of interactions between colloids.

CO3 - Implementing various theories to find e

CO4 - Explaining the conditions for stability of colloid systems.

CO5 - Measuring the magnitudes of interaction forces between colloids.

CO6 - Building a model related to interface in Surface Evolver and solving any colloid interaction problem by numerical programming.

TEXT/REFERENCE BOOKS

1. Jacob N. Israelachvili, Intermolecular and Surface Forces, cademic Press, 1992 or later editions.
2. W. B. Russel, D. A. Saville and W. R. Schowalter, Colloidal Dispersions, ambridge UniversityPress, 1989.

					Carbon Sequestration and Clean Development Mechanism					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
					25	50	25	--	--	100

COURSE OBJECTIVES

1. To better understand about physical/scientific evidence for climate change science
2. To acquire better knowledge about for CO_2 separation from industrial gas streams, sustainable energy production and environment.
3. To understand about CO_2 mitigation through sequestration and utilization
4. To understand about cleaner production linked to CO_2 market and economics

UNIT 1 Climate Change Science **10 Hrs.**

Global warming and climate change: Greenhouse gases, CO_2 emission and Global temperature; scientific data and evidence on climate change: UNFCCC and IPCC roles and reports, Energy and environment, carbon footprint, Global climate models, predictions, stabilization strategies and socio-economic impact.

UNIT 2 Carbon Capture **10 Hrs.**

CO_2 emission from large point sources, Technology options/challenges for clean energy/power production, CO_2 capture technologies: Absorption, Adsorption, membrane separation etc., Process requirements and research needs, CO_2transportation, CO_2 capture case studies and economics. >

UNIT 3 Carbon Sequestration and Utilization **10 Hrs.**

Geological CO_2 storage: storage in aquifer and depleted Oil and gas fields, CO_2 Storage hrough Enhanced Oil Recovery (EOR), Enhanced Coal Bed Methane Recovery, trapping mechanism and CO_2 integrity. CO_2 Utilization: fuels, bio-fuels and chemicals from CO_2, building material form Carbon mineralization, CO_2 curing concrete.

UNIT 4 Clean Development mechanism **10 Hrs.**

UNFCC, IPCC and Kyoto Protocol, Conference of Parties and police making. Cleaner production and flexible mechanisms for CO_2 reduction. CDM Projects: Eligibility, execution and implementation, base line and life cycle; challenges in energy efficiency, solar, wind and conventional fuel power projects, case studies.

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 - Showcase and interpretClimate Change data, predictions and impact on environment>

CO2 - Estimate carbon footprint and analyze power plant technologies for Clean energy production> CO3 - Demonstrate processes for CO_2 separation from industrial flue gas streams >

CO4 - Demonstrate and analyze options for CO_2 sequestration, trapping and integrity, environmental safety >

CO5 - Analyse technology for CO_2 utilization, perceiving advantage/disadvantage/ economic and research needs > CO6 - List and demonstrate CDM projects, base line and life cycle analysis with case studies>

TEXT/REFERENCE BOOKS

1. Climate Change Science: A Modern Synthesis, Volume I: The Physical Climate by G. Thomas Farmer • John Cook, Springer, 2018
2. Clean -Coal engineering Technology by Bruce G.Miller, ISBN 978-0-12-811365-3, @2017 Elsevie
3. Carbon Capture and Storage, second edition by Stephen A. Rackley, ISBN: 978-0-12-812041-5 @2018 Elsevier
4. Clean Development mechanism, CDM Methodologies 11^{th} ed., by UNFCCC, 2019>

					Material Modelling & Simulation Techniques					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To introduce a range of molecular simulation techniques that are used in modelling materials and complex- fluids.
2. To demonstrate the predictive capabilities of these methods by considering a set of applications.
3. To able to learn efficient programming skills in accordance with the methods and algorithms of molecular modelling

UNIT 1 Introduction and general concepts **10 Hrs.**

Objectives and background, Modelling space and time, Examples of chemical engineering & bio medical modelling, Introduction to high performance computing in modelling, concepts of statistical mechanics – partition functions and thermodynamic properties

UNIT 2 Material Simulation techniques – Monte Carlo & Molecular Dynamics **10 Hrs.**

Monte Carlo Simulations: Metropolis algorithm in various ensembles, free energy calculations, configuration bias MC, End-bridging Monte Carlo, lattice Monte Carlo simulations, MC Simulations of polymer melts and thin films, grand canonical MC simulations; Molecular Dynamics Simulations: Basics of Molecular Dynamics Simulations, Numerical algorithms to solve equation of motion, concept of thermostat and barostat, unconstraint and constrained dynamics, Energy minimization, NVT, NPT and NVE ensemble, Introduction to Brownian dynamics

UNIT 3 Quantum Mechanical Modelling **10 Hrs.**

Quantum mechanical model of an atom, From many-body to single-particle: Quantum modeling of molecules, Quantum modeling of solids: Basic properties, QM Modelling of materials and complex fluids

UNIT 4 Applications and real-life problems **10 Hrs.**

Polymers and polyelectrolytes in solutions, adsorption of polymers and surfactants at surfaces/interfaces, transport property calculations (diffusivity, viscosity), Applications of MC and MD techniques for– drug delivery, batteries, CO_2 sequestration, glassy melts

Max : 40 hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – recall and relate the basic concepts of modelling and simulations.

CO2 – outline the application areas in Engineering where concept of molecular modelling & first principles can be applied.

CO3 – choose an appropriate molecular simulation technique and model a material or process

CO4 – analyse the problem statement and compare solutions obtained from different algorithms of MC and MD.

CO5 – estimate the properties (structure, dynamics and thermochemical) of a material or complex fluid using computer simulations.

CO6 – formulate and solve a real-life problem statement by doing thorough literature review of scientific literature.

TEXT/REFERENCE BOOKS

1. Tuckerman M. Statistical mechanics: theory and molecular simulation. Oxford university press; 2010 Feb 11.
2. Leach AR, Leach AR. Molecular modelling: principles and applications. Pearson education; 2001.
3. Frenkel D, Smit B. Understanding molecular simulation: from algorithms to applications. Elsevier; 2001 Oct 19.
4. Gao J, Thompson MA. Combined quantum mechanical and molecular mechanical methods. Washington, DC: American Chemical Society; 1998 Dec 28.
5. Gubbins KE, Quirke N, editors. Molecular simulation and industrial applications: methods, examples, and prospects. Taylor & Francis; 1996.

					Nano-science and Energy Storage					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the fundamentals of Nano Science and Energy Storage.
2. Explain the nanoscale paradigm in terms of properties at the nano scale dimension.
3. Identify current nanotechnology solutions in design, engineering andmanufacturing.
4. To understand the use of nanotechnology in Energy Storage.

UNIT I Introduction of Nanoscience and technology 10 hrs

Introduction of Nanoscience and technology, Nanoparticles and their properties, Case studies demonstrating non- classical behavior at nanoscale in successful and emergenttechnologies, Quantum Mechanics, Chemical Kinetics at nano-scale.

Unit –II Synthesis of Nanomaterials 10 hrs

Chemical Routes for Synthesis of Nanomaterials: Chemical precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Solvothermal synthesis; Thermolysis routes, Microwave heating synthesis; Sonochemical synthesis; Electrochemical synthesis; , Photochemical synthesis, Synthesis in supercritical fluids.

Unit III characterization technique 12 hrs

Detailed characterization technique based on radiation matter interactions and their analytical applications like Scanning Electron, Transmission electron microscope, Atomic force microscope, scanning tunneling microscope and spectroscopy will be used in interpreting the nano structured objects.

Unit-IV Applications 10 hrs

Fuel Cells, Polymer membranes for fuel cells, PEM fuel cell. Acid/ alkaline fuel cells, design of fuel cells, Carbon Nanotubes for energy storage, Hydrogen Storage in Carbon Nanotubes, Use of nanoscale catalysts to save energy and increase the productivity in industry, Rechargeable batteries based on nanomaterials, Nanocomposites for electrodes and electrolyte applications. The safety and energy storage issues and the impact of nanotechnology on the environment will be stressed at the end.

Max:- 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to
CO1:- Tell the basics of Nano-science and technology along with properties.
CO2:- Explain the chemical methods for synthesis of nanoparticles.
CO3:- Develop various nanomaterials and basic understanding in the relevant analytical techniques.
CO4:- Categorize the various techniques for nano-materials characterization.
CO5:- Explain the physical methods for design of fuels cells, carbon nanotubes for energy storage.
CO6:- Discuss the use of nanotechnology in Energy Storage.

TEXT/REFERENCE BOOKS

1. Nanoscale science and technology, John Wiley & Sons.,2005.
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press,2009.
3. Sula7yubha K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Company,2007.
4. Nanobiotechnology, concepts, applications and perspectives, Wiley-VCH,2004.
5. Ozin G. A, Andre C. Arsenault, Nanochemistry A chemical approach to nanomaterials, Royal society of chemistry,UK,2005.

<Course Code>					Computational Fluid Dynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Introduce the student to various discretization schemes.
2. To provide understanding of various solution schemes.
3. Implementation of CFD in softwares.

UNIT 1 Introduction to Computational Fluid Dynamics [CFD] 10 Hrs.

Introduction to Computational Fluid Dynamics and its applications, Revisting transport equations and their coupling, and various boundary conditions. Quick introduction to Numerical Methods.

UNIT 2 Discretization 10 Hrs.

Discretization principles: Pre-processing, Solution, Post-processing, Finite Element Method, Finite difference method, Well-posed boundary value problem, Possible types of boundary conditions, Conservativeness, Boundedness, Transportiveness, Finite volume method (FVM), Illustrative examples:1-D steady state heat conduction with and without constant source term.

UNIT 3 Methods of Solution 10 Hrs.

Solution of finite difference equations, iterative methods, matrix inversion methods, ADI technique, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations, operator splitting, Fast Fourier transform.

UNIT 4 CFD using programming and Open FOAM 10 Hrs.

Development of simple CFD codes in Python or Julia. Introduction to Open FOAM, defining geometry and mesh, implementation of solvers. Solution to some basic problems related to heat transfer and fluid flow in Open FOAM.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 -Highlighting basic transport equations and boundary conditions.

CO2 -Associating coupled fluid dynamics problems with numerical analysis.

CO3 –Choose an appropriate discretization method.

CO4 -Breaking-down a CFD problem in various parts. CO5 -Assess various solution schemes in CFD.

CO6 -Programming using Python/Julia and Building CFD codes in Open FOAM.

TEXT/REFERENCE BOOKS

1. Computational Fluid Dynamics, T. J. Chung, Cambridge University Press, 2010.
2. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.
3. Computational Fluid Dynamics, J. D. Anderson Jr., McGraw-Hill International Edition, 1995.

Course Code: XXXXXX					Research Methodology					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the role of research in the field of engineering and get an overview of the research process.
2. To develop proficiency in literature review techniques.
3. To understand the process of formulating and solving research problems.
4. To understand different types of intellectual property rights.

UNIT I : Introduction to Research **06 Hrs.**

Role of research in engineering, research process overview, types of research, outcomes of research, characteristics of a researcher, research terminology

UNIT II : Literature Review Techniques **06 Hrs.**

Searching for the existing literature, reviewing the selected literature, developing a theoretical framework, developing a conceptual framework

UNIT III : Formulating and Solving a Research Problem **08 Hrs.**

Importance of formulating a research problem, sources of research problems, identifying a problem, formulation of research objectives and research questions, Need for research design, different research designs, experimental test-setups, data sampling, data collection, data analysis & interpretation

UNIT VI: Intellectual Property Rights **08 Hrs.**

Introduction and significance of intellectual property rights, types of intellectual property rights, introduction to patents, patent drafting and filing, copyright, trademarks, industrial design, geographical indicators

Total **28 Hrs.**

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 - **understand the role and significance of research in engineering**
CO2 - develop understanding of the basic framework of research process and design
CO3 - identify technical gaps in the literature and formulate a problem.
CO4 - develop an understanding of various research designs and techniques.
CO5 - develop an understanding of the ethical dimensions of conducting applied research
CO6 - evaluate and apply intellectual property rights concepts to the research outcomes

Reading Material

1. Stuart Melville, Wayne Goddard, Research Methodology: An Introduction for Science and Engineering Students, Juta & Co. Ltd.
2. David V. Thiel, Research Methods for Engineers, Cambridge University Press, UK
3. Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, Pearson
4. CR Kothari, Research Methodology (Methods and Techniques), New age Publications

Semester II

COURSE STRUCTURE FOR M.TECH. ENERGY AND ENVIRONMENTAL MANGEMENT FIRST YEAR SEM – II (w. e. f 2024-25)

SEMESTER-II (Subjects)				M.TECH._Sem.-II										
Sr. No	Course Code	Category Code	Course Name	Teaching Scheme					Exam Scheme					Total Marks
									Theory			Practical		
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	
1		PCC	Environmental Science and Engineering	3	0	0	3	3	25	50	25			100
2		PCC	Advanced Energy and Environmental Engineering Lab	0	0	2	1	2	-	-	-	50	50	100
3		PCE	Professional Core Elective_L - 1	3	0	0	3	3	25	50	25			100
4		PCE	Professional Core Elective_L - 2	3	0	0	3	3	25	50	25			100
5		PCE	Professional Core Elective_L - 3	3	0	0	3	3	25	50	25			100
6		PCE	Professional Core Elective_L - 4	3	0	0	3	3	25	50	25			100
7		Project	Research Methodology and IPR	2	0	0	2	2	25	50	25	-	-	100
8		Project	Seminar	-	-	-	1	-	-	-	-	50	50	100
			Total	**17**	**0**	**2**	**19**	**19**						

Elective Baskets

PCE1	**Elective Basket 1**
	Unit Operations and Processes in Environmental Engineering Theory
	Energy Conversion Device Engineering Theory
PCE2	**Elective Basket 2**
	Integrated Waste Management And Environmental Economics
	Renewable & Non-Renewable Energy
PCE3	**Elective Basket 3**
	Environmental Audit and Impact Assessment
	Life Cycle Assessment
PCE4	**Elective Basket 4**
	Energy and Environment Ecosystem
	Energy & Environment – Policy, Planning & Auditing

					Environmental Science and Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the basics approaches of environmental science and engineering.
2. To understand and identify air pollutants and control techniques.
3. To identify and understand treatment approach for water pollution.
4. To identify and understand solid, hazardous and plastic waste management.

UNIT 1 – BASICS OF ENVIRONMENT SCIENCE **10 h**

Basics of environment Science-definition, scope and importance, environmental impact assessment, environmental risk assessment, Emerging environmental issues with air, water, wastewater and solid wastes. Environmental protection Act, Air (Prevention and Control of Pollution) act – Water (Prevention and control of Pollution) act.

UNIT 2 – AIR POLLUTION AND CONTROL **10 h**

Concept of air pollutants, air pollution sources and its dependence on the atmospheric factors, atmospheric stability and dispersion of pollutants. Control of emission of pollutants using settling chamber, multi-cyclone systems, electrostatic precipitators, bag filters, wet scrubbers for gas cleaning, absorption, adsorption by activated carbon etc.

UNIT 3 – WATER AND WASTEWATER TREATMENT **12 h**

Physical, chemical characteristics and microbiology of wastewater, BOD kinetics, Concept of inorganic and organic wastes and definition of BOD and COD. Control of water pollution: primary treatment-(Equalization tank, sedimentation, coagulation-flocculation, sand filters), biological treatment-(activated sludge process, trickling filters, aerated lagoons) systems, sludge treatment and tertiary treatment-(disinfection, membrane separation, ion- exchange).

UNIT 4 – SOLID AND HAZARDOUS WASTE MANAGEMENT **8 h**

Municipal solid waste management systems: Composition and characteristics of solid waste, treatment, 3Rs, disposal methods (recycling, landfills, composting, incineration). Hazardous waste treatment: identification, minimization and treatment. Plastic waste and e-waste management: recovery and reuse.

Max. 40 h

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 –Define the basic knowledge of environmental science and environmental Laws. CO2 –Classify air and water pollutants and their effects on living and non-living things.

CO3 –Apply knowledge in municipal solid waste, hazardous waste, plastic waste and e-waste management.

CO4 –Analyze the physical, chemical and biological properties of water.

CO5 –Estimate the efficiency and performance of particulate emission control devices.

CO6 – Design different treatment units involved in minimization and treatment of polluted water.

TEXT/REFERENCE BOOKS

1. M.L. Mckinney, “Environmental Science” Printed in the United States of America.
2. H. S. Peavy, "Environmental Engineering", McGraw-Hill, International Ed., New York - 1985.
3. Metcalf & Eddy, "Waste Water Engineering: Treatment, Disposal, Reuse", 2nd Ed., McGraw-Hill, New York -
4. 1979.J. K. Sharma, Operations research Theory and Applications, MacMillan, 5th edition

					Advanced Energy and Environmental Engineering Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	00	00	00	50	50	100

COURSE OBJECTIVES

1. To explore various techniques for synthesizing energy efficient materials.
2. To develop skills in data collection, analysis and interpretation.
3. To learn the principles of various instruments and their application in analyzing samples.
4. To develop practical skills, deepen their understanding of fundamental principles, and prepare themselves for real-world applications.

LIST OF EXPERIMENTS:

1. To study various techniques for Synthesis of Energy Efficient Nanomaterials
2. To study the batch adsorption characteristics of water contaminants using synthesized adsorbents
3. To study the membrane preparation and characterization for water treatment.
4. To study membrane separation characteristics of oil in water emulsion system.
5. Gas Chromatographic analysis of gases.
6. To study principle, construction and working of UV visible Spectrometer
7. To study principle, construction and working of FTIR Spectrometer
8. To study principle, construction and working of SEM, FESEM and Transmission electron microscopy

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Recall principles and techniques involved in the synthesis of energy-efficient materials.

CO2: Understand the mechanisms of adsorption and membrane separation processes for water treatment.

CO3: Apply membrane preparation and characterization techniques for water treatment.

CO4: Analyze chromatograms, data from UV and spectra to identify and quantify compounds.

CO5: Evaluate the quality and usefulness of electron microscopy images for material characterization.

CO6: Design experiments for material synthesis and create reports summarizing experimental procedures, results, and conclusions.

Course Code					Integrated Waste Management and Environmental Economics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand basics of waste management and waste treatment technologies
2. To learn the importance of integrated waste management
3. Get acquaintance with waste management systems
4. Study the linkage between economic growth and pollution and Role of economics in waste handling

UNIT 1 –INTRODUCTION TO WASTE MANAGEMENT 10 Hrs.

Waste-Definition, characteristics, sources, classification, physico-chemical properties, segregation, characterization, generation, quantification, transportation, collection systems, transfer stations, collection route optimization, regulations, Treatment methods, processing of waste, waste minimization, waste exchange, recovery, recycling. Treatment methods-Physical, chemical, thermos-chemical, biological

UNIT 2 – INTEGRATED WASTE MANAGEMENT AND RULES 8 Hrs.

Integrated waste management, waste management hierarchy, methods and importance of waste management, policies of waste management, Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Plastic Waste (Management and Handling) Rules, 2011; E-Waste (Management) Rules, 2016

UNIT 3 – WASTE TREATMENT AND DISPOSAL 10 Hrs.

Landfill management and regulations, solidification, open dumping, site selection, sanitary land fill, design criteria an design examples, leachate and gas collection system, Incineration and waste-to-energy technologies, composting and organic waste management, hazardous waste management and remediation, policies for controlling air and water pollution, disposal of toxic and hazardous waste- standards vs. emissions charges

UNIT 4 – ENVIRONMENTAL ECONOMICS 12 Hrs.

Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and valuation: discounting, principles of Cost-Benefit Analysis, adjusting and comparing environmental benefits and costs. Social costs and benefits of environmental programs: marginal social benefit of abatement, marginal social cost of abatement; environmental subsidies, modelling and emission charges; polluter pay principles; pollution permit trading system.

TOTAL HOURS: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : **Explain** the need of integrated waste management.
CO2 : **Illustrate** skills in the understanding of policies and rules of waste management.
CO3 : **Choose** the technologies available for the processing of different solid wastes and to mitigate the growing solid wastes.
CO4 : **Analyze** the various solid, air and water pollution abatement technologies.
CO5 : **Evaluate** the economic potential of waste feed stocks.
CO6 : **Maximize** the income obtained from the processing of wastes.

TEXT/REFERENCE BOOKS

1. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.
2. McDougall, F.R., White, P. R., Franke, M., &Hindle, P. 2008. Integrated Solid Waste Management: A Life Cycle Inventory. John Wiley & Sons
3. Tietenberg, T. H. & Lewis, L. 2010. Environmental Economics and Policy. Addison-Wesley
4. Singh, K. &Shishodia, A. 2007. Environmental Economics: Theory and Applications. Sage Publications

<course Code>					Environmental Audit and Impact Assessment					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To provide learning of basics of EIA, its terminology, strategies, shortcoming and affecting factors.
2. To understand rules, regulations, notifications, guidelines and compliance requirements for EIA study
3. To get an insight and deep learning of EIA framework and its methodologies
4. To learn about environment audit, structure, protocol of audit and its evaluation

UNIT 1 BASICS OF ENVIRONMENT IMPACT ASSESSMENT 08 Hrs.

Scope and terminologies, EIA and sustainable development, benefits, drawbacks, strategic environmental assessment and social impact assessment, initial environmental examination, elements of EIA, factors affecting, impact evaluation and analysis, preparation of environmental base map, classification of environmental parameters.

UNIT 2 POLICIES, LEGISLATION AND PROCEDURES 10 Hrs.

Environmental Clearance; Forest clearance; Consent to Establish & Consent to Operate; Environmental conservation plan for endangered flora and fauna, National Policies, EIA notifications, EIA Guidelines and compliance requirements, administrative procedures in India and states, Accreditation, Requirements and guidelines, EIA in foreign countries.

UNIT 3 EIA METHODOLOGIES 12 Hrs.

Framework for EIA, Screening, Baseline studies, EIA planning, Activities, Methodology for EIA, Role of Environmental Engineering, Criteria for the selection of EIA Methodology, EIA methods, Ad-hoc methods, matrix methods, Network method Environmental Media Quality Index method, overlay methods, cost/Benefit Analysis

UNIT 4 ENVIRONMENT AUDIT 10 Hrs.

Environmental Audit, objectives, types, elements of an audit process and its importance, environment audit in India, audit protocol, stages of environmental audit, audit tools and technology/general audit methodology and basic structure of audit,evaluation of audit data and preparation of audit report, post audit activities, case studies.

COURSE OUTCOMES

CO1 – Relate to the basics of EIA, different terminologies, strategies, and showcase its utility to Industrial projects
CO2 –Demonstrate the compliance requirements in an EIA study of any project
CO3 – Identify different rules, regulations, and guidelines to plan for an approval of a project
CO4 – Analyze the EIA framework, and evaluate its methodologies for study
CO5 – Appraise to the environment audit practices and protocol
CO6 – Elaborate the understanding of EIA and formulate an EIA study report for a proposed project

TEXT/REFERENCE BOOKS

1. Larry Canter, Environmental impact Assessment, McGraw Hill International Edition, 1997
2. J. Glynn Henry, Gary W. Heinke, Environmental Science and Engineering, Pearson Publisher, 1988
3. J Glasson, R Therivel, A Chadwick, Intro. to Environmental Impact Assessment, Routledge Taylor and Francis, 1994

Curriculum 2024										
					Life Cycle Assessment					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES:

1. To introduce the students to the concept of life cycle thinking.
2. To deal with environmental pollution problems and make use of Life Cycle Assessment (LCA) as an assessment tool
3. To expose the application of LCA to waste management and energy conversion systems

UNIT 1 <Introduction and need of LCA > 7 Hrs.

An Introduction to Sustainability, Energy and Environment aspects: (Environment: The magnitude of sustainability challenge, Material use, Environmental emissions, Environmental interactions – biogeochemical cycles; Energy: Energy Demand and Supply, Scenario Techniques) Economic and Social dimensions, need for LCA

UNIT 2 <Overview of the Life Cycle Assessment Method > 13 Hrs.

Life Cycle Analysis: Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools; limitations with LCA; history of LCA

UNIT 3 < LCA in Environment Management > 10 Hrs.

LCA of Greenhouse Gases; Application of LCA in Strategic Environmental Assessment; Application of LCA in waste management, Application of LCA in environmental certification (ISO 14001 compliance with EMS)

UNIT 4 <LCA in Energy > 10 Hrs.

Life-Cycle Analysis of Primary and Intermediate Energy Conversion; Application of LCA in assessing energy systems (refining, power plant, biofuels (fuel vs electric vehicle, gas vs fuel oil, etc.); Life-Cycle Analysis of End-Use Energy Conversion (transportation, building and space conditioning etc.)

Max. 40 Hrs.

COURSE OUTCOMES

CO1 - Learn basic concepts of life cycle assessment (LCA)
CO2 - Explain the overall purpose and principles of LCA.
CO3 - Discuss possible applications and limitations of LCA
CO4 - Examine and assess a complete LCA of a product or service system
CO5 - Write a report of the performed LCA and apprise its compliance with ISO standards for LCA>
CO6 - Make a critical review of alternative LCA

TEXT/REFERENCE BOOKS

1. US EPA manual on ‘Life Cycle Assessment: Principles and Practice; EPA/600/R-06/060 May 2006>
2. W. Klöpffer, 'Background and Future Prospects in Life Cycle Assessment’, Springer Netherlands, 2014
3. M A Curran, 'Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products', Scrivener-Wiley, 2012
4. Bent Sørensen,'Life-Cycle Analysis of Energy Systems; From Methodology to Applications', RSC Publishing, 2011
5. *For Case studies: Few major journals for papers on LCA*
6. Journal of Industrial Ecology, International Journal of Life cycle Assessment, Environmental
7. Science and Technology, Journal of Cleaner Production, Journal of Environmental Management, Energy.

<>					Energy and Environment Ecosystem					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To develop an insight and understanding on co-relation between energy and environment
2. Impart knowledge on energy and environment management
3. To impart knowledge on concept of sustainability and energy conservation
4. To inculcate concern on Environment degradation and remedial solutions

UNIT 1:ECOSYSTEM AND GENERAL AWARENESS **12 Hrs**

Concepts of ecosystems and environment, Characteristics and types of ecosystems, Autecology and synecology, Energy flow in ecosystems, Eco-technology and Eco-development, Interrelationship between energy and environment, Energy Scenario and Classification: Primary & Secondary energy, Non-renewable & renewable energy, Globally energy reserves and production, Energy and environment conservation and importance.

UNIT 2: ENERGY-ENVIRONMENT INTERACTION **10 Hrs**

Natural Resources- Water Resources, Availability and Quality aspects. Water borne diseases, Water Induced diseases, Fluoride problem in drinking water. Mineral Resources, Forest Wealth, Material cycles- Carbon, Nitrogen and Sulphur Cycles. Electro-magnetic radiation. Conventional and Non-Conventional sources - Hydro Electric, Fossil Fuel based Nuclear, Solar, Biomass and Biogas. Hydrogen as an alternative future source of Energy.

UNIT 3: GLOBAL ISSUES AND NEED FOR ENERGY CONSERVATION **9 Hrs**

Air Pollution, Acid rain, Ozone layer, depletion, global warming and climate change, loss of biodiversity. Need for conservation, Strategies for Energy Conservation, Clean Development Mechanism (CDM), and Sustainable development.

UNIT 4: ECOLOGY **9 Hrs**

Ecology – definitions, Biodiversity, Examples of Historical Impact of economy and pollution on Ecology, Restoration / Ecological Engineering. Pollution and Waste Management, environmental ethics, United Nations Framework Convention on climate change (UNFCCC), National action plan on climate changes, Kyoto Protocol, Environmental Protection- Role of Government/Public

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: To **define** ecosystem and **relate** to the synergy between energy and environment
CO2: To **demonstrate** knowledge of different resources and **outline** their relationship with ecology & environment
CO3: To **identify** the effect of harnessing energy on global climatic change and ecology
CO4: To **analyze** and **discover** the need for energy conservation and control measures for enabling rational use of energy
CO5: To **mark** the **influence** of global issues and **determine** remedial solutions for sustainable development
CO6: To **predict** the impact on ecology and environment and **develop solutions** for mitigating climate change and ensure environment protection

TEXT/REFERENCE BOOKS

1. Gilbert M. Masters and Wendell P. ELA – Introduction to Environmental Engineering And Science
2. W. Cunningham – Principles of Environmental Science, TMH
3. P. Venugoplan Rao – Principles of Environmental Science and Engineering, PHI.
4. Kreith F., Goswami D.Y. (2007). Energy Management and Conservation Handbook. CRC Press. ISBN: 9781420044294.
5. Energy Management Supply and Conservation, Dr. Clive Beggs, Butterworth Heinemann, 2002.

Course Code					Energy and Environmental-Policy, Planning and Auditing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand energy scenario and general aspects of energy audit
2. Learn about methods and concept of energy audit and necessity of conservation of energy
3. To familiarize to the methods of energy management and practices
4. Understand the energy utilization pattern, energy auditing and perform economic analysis

UNIT 1 – BASICS OF ENERGY AND IT'S RESOURCES **10 Hrs.**

Current trends in energy production and consumption, world energy flows, national energy plan, energy and economic growth, supply and availability; understanding energy costs, bench marking, matching energy use to requirement, maximizing system efficiencies, optimizing energy requirements, duties and responsibilities of energy auditors, energy audit instruments, procedures and techniques for cost benefit analysis – carbon credit and footprint.

UNIT 2 – ENERGY AND ENVIRONMENT PLANNING AND POLICIES **12 Hrs.**

Energy demand analysis and forecasting, Energy supply assessment and evaluation, Energy demand – supply balancing, Energy models. Energy – economy interaction, Energy investment planning and project formulation. Policy and planning implications of energy – environment interaction, Clean development mechanism. Energy policy related acts and regulations. Software for energy planning.

UNIT 3 – ENERGY MANAGEMENT SYSTEM **8 Hrs.**

Principles of energy management, design and development of energy management program, initiating, planning, controlling, promoting, monitoring, reporting, energy manger, qualities, duties and functions, preparation and presentation of energy audit reports, case studies of energy management

UNIT 4 – ECONOMIC ANALYSIS OF ENERGY SYSTEMS **10 Hrs.**

Economics analysis, depreciation methods, time value of money, rate of return, present worth method , replacement analysis, life cycle analysis, energy efficient electrical instruments, calculation of payback period, net present worth method, power factor correction, lighting – applications of life cycle analysis, return on investment

TOTAL HOURS: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 : Relate to the basics of energy, its resources and need of audit system to the Industry
CO2 : Understand the synergy between energy and environment connecting policies and planning
CO3 : Identify the duties and functions of energy manager and his role in EMS
CO4 : Analyze the EMS framework, and its methodologies for energy auditing
CO5 : Appraise to the energy audit practice, evaluate the impact on environment and perform the economic analysis
CO6 : Elaborate the understanding of Energy Auditing and identify energy saving potential

TEXT/REFERENCE BOOKS

1. Murphy, W. R., Energy Management, Elsevier, 2007.
2. Smith, C. B., Parmenter K., Energy Management Principles, Pergamon, 1981
3. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
4. Energy and the Challenge of Sustainability, World energy assessment, UNDP New York, 2004.
5. AKN Reddy, RH Williams, TB Johansson, Energy after Rio, Prospects and challenges, UNDP, United Nations Publications, New York, 1997.
6. Nebojsa Nakicenovic, Arnulf Grubler and Alan McDonald "Global energy perspectives", Cambridge University Press, 1999.
7. Fowler, J.M, "Energy and the environment", McGraw Hill, 1984.
8. Robert Ristirer and Jack P. Kraushaar, "Energy and the environment", Wiley, 2005.

Semester III

COURSE STRUCTURE FOR M.TECH. CHEMICAL ENGINEERING SECOND YEAR SEM – III (w. e. f 2024-25)

SEMESTER-III (Subjects)				M.TECH. Sem. - III										
				Teaching Scheme					Exam Scheme					
Sr. No	Course Code	Category Code	Course Name						Theory			Practical		Total
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	Marks
1		Project	Project Phase - I	-	-	-	13	-	-	-	-	50	50	100
2		Project	Summer Internship /IEP (6 Week)	-	-	-	1	-	-	-	-	50	50	100
			Total	**0**	**0**	**0**	**14**	**-**						

Semester IV

COURSE STRUCTURE FOR M.TECH. CHEMICAL ENGINEERING SECOND YEAR SEM – IV (w. e. f 2024-25)

SEMESTER-IV (Subjects)				M.TECH._Sem. - IV										
				Teaching Scheme					Exam Scheme					
Sr. No	Course Code	Category Code	Course Name						Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	MS	ES	CE	LE	LE/Viva	
1		Project	Project Phase – II and Dissertation	-	-	-	16	-	-	-	-	50	50	100
			Total	**0**	**0**	**0**	**16**	**-**						

MS = Mid Semester, ES = End Semester; CE = Continuous Evaluation LW = Laboratory work; LE = Laboratory Exam