Pandit Deendayal Energy University

School of Energy Technology

Academic Architecture and Syllabus

for

B.Tech in Chemical Engineering

2024

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.

B. Tech. Semester 1

Group 2

1. **Electronics and Communication Engineering**
2. **Civil Engineering**
3. **Mechanical Engineering**
4. **Chemical Engineering**
5. **Biotechnology**

Course Code	Course Name	Th	Tut	Pra	Hrs	Cr
24MA101T	Mathematics - I	3	1	0	4	4
24MA102T	Mathematics for Biotechnology – I (Applicable for Biotechnology Only)					
24HS101T	English Communication	2	0	0	2	2
24CP101T	Computer Programming - I	1	0	0	1	1
24CP101P	Computer Programming - I Laboratory	0	0	2	2	1
24CH101T	Engineering Chemistry	3	0	0	3	3
24CH101P	Engineering Chemistry Laboratory	0	0	2	2	1
24EE101T	Elements of Electrical and Electronics Engineering	3	0	0	3	3
24EE101P	Elements of Electrical and Electronics Engineering Laboratory	0	0	2	2	1
24BT101T	Biological Systems for Engineers	2	0	0	2	2
24BT102T	Biology for Engineers					
24HS104T	Organizational Behaviour	1	0	0	1	1
24YOG101	Yog, Health & Hygiene	0	0	2	2	1
24NSS101	National Service Scheme (NSS)					
24NCC101	National Cadet Corps (NCC)					
		15	**1**	**8**	**24**	**20**

B. Tech. Semester 2
Group 2

1. **Electronics and Communication Engineering**
2. **Civil Engineering**
3. **Mechanical Engineering**
4. **Chemical Engineering**
5. **Biotechnology**

Course Name	Course Code	Th	Tut	Pra	Hrs	Cr
24HS105T	Professional Communication	2	0	0	2	2
24MA103T	Mathematics - II	3	1	0	4	4
24MA104T	Mathematics for Biotechnology – II (Applicable for Biotechnology Only)					
24CP102T	Computer Programming – II	1	0	0	1	1
24CP102P	Computer Programming Laboratory – II	0	0	2	2	1
24PH101T	Applied Physics (Only For ECE)	3	0	0	3	3
24PH102T	Engineering Physics (Only For Mechanical and Civil)					
24PH103T	Modern Physics (Only For Biotechnology and Chemical)					
24PH101P	Applied Physics Laboratory (Only For ECE)	0	0	2	2	1
24PH102P	Engineering Physics Laboratory (Only For Mechanical and Civil)					
24PH103P	Modern Physics Laboratory (Only For Biotechnology and Chemical)					
24ME101P	Workshop Practices	0	0	2	2	1
24ME102P	Engineering Graphics	0	0	4	4	2
24CV101T	Environmental Science	2	0	0	2	2
24HS102T	Universal Human Values	1	0	0	1	1
24HS103T	Indian Knowledge System	2	0	0	2	2
		14	**1**	**10**	**25**	**20**

UG Curriculum (2024 onwards)

Year-2

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 3	Pro		Civic and Social Service Internship	0	0	2	2	1
	BSC		Maths-III	3	1	0	4	4
	ESC		Introduction to Artificial Intelligence	3	0	0	3	3
	PC		Chemical Process Calculations	3	1	0	4	4
	PC		Mechanical Unit Operations	3	0	0	3	3
	PC Lab		Mechanical Unit Operations Lab	0	0	2	2	1
	PC		Fluid Mechanics	3	0	0	3	3
	PC Lab		Fluid Mechanics Lab	0	0	2	2	1
				15	**2**	**6**	**23**	**21**
Semester 4	Pro		Industrial Orientation	0	0	0	0	0
	OE		Open Elective 1 (Inter-School)	3	0	0	3	3
	ESC		Chemical Engineering Industry 4.0	2	0	0	2	2
	ESC Lab		Chemical Engineering Industry 4.0 Lab	0	0	2	2	1
	PC		Introduction to Numerical Methods for Chemical Engineers	3	1	0	4	4
	PC		Chemical Engineering Thermodynamics	3	0	0	3	3
	PC Lab		Chemical Engineering Thermodynamics Lab	0	0	2	2	1
	PC		Heat Transfer	3	0	0	3	3
	PC Lab		Heat Transfer Lab	0	0	2	2	1
	PC		Chemical Process Technology	3	0	0	3	3
	PC Lab		Chemical Process Technology Lab	0	0	2	2	1
				17	**1**	**8**	**26**	**22**

UG Curriculum (2024 onwards)

Year-3

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 5	OE		Open Elective 2 (NPTEL/SWAYAM/MOOC)	3	0	0	3	3
	HSC		Engineering Economics	3	0	0	3	3
	PE		Program Elective 1	3	0	0	3	3
			Petroleum Refining & Petrochemicals					
			Renewable Energy Engineering					
			Sustainability & Green Chemistry					
	PC		Mass Transfer 1	3	0	0	3	3
	PC Lab		Mass Transfer 1 Lab	0	0	2	2	1
	PC		Chemical Reaction Engineering 1	3	0	0	3	3
	PC Lab		Chemical Reaction Engineering 1 Lab	0	0	2	2	1
	PC		Process Equipment Design	3	0	0	3	3
	PC Lab		Process Equipment Design Lab	0	0	2	2	1
				18	**0**	**6**	**24**	**21**
Semester 6	OE		Open Elective 3 (Inter-department, FoET)	3	0	0	3	3
	PE		Program Elective 2	3	0	0	3	3
			Piping Design					
			Corrosion Engineering					
			Material Science & Engineering					
	PE		Program Elective 3	3	0	0	3	3
			Nano Technology & Energy Storage					
			Membrane Processes					
			Environmental Engineering and Pollution Control					
	PC		Instrumentation & Process Control	3	0	0	3	3
	PC Lab		Instrumentation & Process Control Lab	0	0	2	2	1
	PC		Mass Transfer 2	3	0	0	3	3
	PC Lab		Mass Transfer 2 Lab	0	0	2	2	1
	PC		Chemical Reaction Engineering 2	3	0	0	3	3
	PC Lab		Chemical Reaction Engineering 2 Lab	0	0	2	2	1
				18	**0**	**6**	**24**	**21**

UG Curriculum (2024 onwards)

Year-4

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 7	Pro		Summer Internship	0	0	0	0	2
	OE		Open Elective 4 (Inter-department, FoET)	3	0	0	3	3
	PE		Program Elective 3	3	0	0	3	3
			Polymer Science & Technology					
			Energy Conversion Device Engineering					
			Pharmaceuticals Technology					
	PE		Program Elective 5	3	0	0	3	3
			Process Plant Safety, Health, and Hygiene					
			Project Management					
			Plant Design & Process Economics					
	PC		Process Modelling and Optimization	3	0	0	3	3
	PC Lab		Process Modelling and Optimization Lab	0	0	2	2	1
	PC		Computer Aided Process Design	3	0	0	3	3
	PC Lab		Computer Aided Process Design Lab	0	0	2	2	1
	PC		Transport Phenomenon	3	1	0	4	4
	Pro		Seminar	0	0	0	0	0
				18	**0**	**6**	**24**	**21**
Semester 8	**Category Code**	**Course Code**	**Course Name**	**Theory**	**Tutorial**	**Practical**	**Hrs**	**Credits**
	Pro		Major/Comprehensive Project	0	0	26	26	13
				0	**0**	**26**	**26**	**13**

B. Tech. Semester 1

Group 2

1. **Electronics and Communication Engineering**
2. **Civil Engineering**
3. **Mechanical Engineering**
4. **Chemical Engineering**
5. **Biotechnology**

Course Code	Course Name	Th	Tut	Pra	Hrs	Cr
24MA101T	Mathematics - I	3	1	0	4	4
24MA102T	Mathematics for Biotechnology – I (Applicable for Biotechnology Only)					
24HS101T	English Communication	2	0	0	2	2
24CP101T	Computer Programming - I	1	0	0	1	1
24CP101P	Computer Programming - I Laboratory	0	0	2	2	1
24CH101T	Engineering Chemistry	3	0	0	3	3
24CH101P	Engineering Chemistry Laboratory	0	0	2	2	1
24EE101T	Elements of Electrical and Electronics Engineering	3	0	0	3	3
24EE101P	Elements of Electrical and Electronics Engineering Laboratory	0	0	2	2	1
24BT101T	Biological Systems for Engineers	2	0	0	2	2
24BT102T	Biology for Engineers					
24HS104T	Organizational Behaviour	1	0	0	1	1
24YOG101	Yog, Health & Hygiene	0	0	2	2	1
24NSS101	National Service Scheme (NSS)					
24NCC101	National Cadet Corps (NCC)					
		15	**1**	**8**	**24**	**20**

24MA101T					Mathematics – I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To be able to evaluate problems related to differential and integral calculus of complex functions.
2. To be able to obtain area, volume using integral calculus.
3. To be able to formulate and solve various engineering problems using the calculus.
4. To study the properties of sequence and series and to check the convergence and divergence.

UNIT I: DIFFERENTIAL CALCULUS AND ITS APPLICATIONS **08 Hrs.**

Partial derivative and its application - Euler's theorem - Total derivatives - Jacobians – Maxima and Minima of two variables using Lagrange's multipliers. Taylor's series, Convergence of power series.

UNIT II: INTEGRAL CALCULUS AND ITS APPLICATIONS **12 Hrs.**

Definition and evaluation of double integral (Cartesian – Polar form) – Change of orders - Change of variables – Evaluation of triple integral, change of variables (Cartesian to spherical – and cylindrical) – Applications, area – volume – center of mass – center of gravity by double and triple integral.

UNIT III: VECTOR CALCULUS **10 Hrs.**

Gradient, divergence and curl – Directional derivative – Irrotational and Solenoidal vector fields – Vector Integration – Simple problems on line, surface and volume integrals – Green's theorem in a plane, Gauss divergence theorem and Stokes' theorem (without proofs) – Simple application involving cubes and rectangular parallelepipeds.

UNIT IV: SEQUENCE AND SERIES **12 Hrs.**

Definition. Convergent, divergent, bounded & monotone sequences. Infinite sums: Basics Taylor series, Convergence and divergence, Tests for convergence for positive term series, Alternating series – Leibnitz test, Absolute convergence, conditional convergence.

TOTAL: 42 Hrs.

COURSE OUTCOMES

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

CO1 : Identify the use of convergence of infinite series in engineering aspects.
CO2 : Understand the concept of Directional derivative, Irrotational and Solenoidal vector fields.
CO3 : Apply the concept of differential and integral calculus in engineering problems.
CO4 : Analyze the obtained solution in linear and non-linear domains.
CO5 : Appraise mathematical problems from complex domain.
CO6 : Evaluate problems on Green's, Stokes' and Divergence theorems.

TEXT/REFERENCE BOOKS

1. B. S Grewal, Higher Engineering Mathematics, Khanna Pub.
2. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Alpha Science.
3. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley.
4. G. Strang, Linear Algebra and its Applications, Cengage Learning.
5. K. Hoffman and R. A. Kunze, Linear Algebra, Prentice Hall of India.

24MA102T					Mathematics for Biotechnology – I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To make students acquainted with the basics of sets, relations, and functions
2. To learn the fundamentals of differential and integral calculus.
3. To understand the use of calculus in real-world applications.
4. To introduce the concept of matrix, determinants, and their use to solve systems of equations.

UNIT I: SET RELATIONS AND FUNCTIONS **10 Hrs.**

Sets and their representation. Union, intersection, and complement. Mapping or function. One-one, onto mappings. Inverse and composite mappings.

UNIT II: BASICS OF DIFFERENTIAL CALCULUS **10 Hrs.**

Limit, continuity, Differentiability of elementary functions, Increasing and Decreasing Functions, Maxima and Minima.

UNIT III: BASICS OF INTEGRAL CALCULUS **10 Hrs.**

Integrals of elementary functions. Substitution and partial fractions. Definite Integral as a limit of sum. Properties of definite integrals. Application to areas and arc lengths.

UNIT IV: MATRICES AND DETERMINANTS **12 Hrs.**

Algebra of matrices. Determinant of a square matrix. Properties of determinants. Some simple types of matrices. The inverse of a matrix. The rank of a matrix, consistency of the system of linear equation upto 3^{rd} order. Eigen values and Eigenvectors of a real matrix, Properties of Eigen values and Eigen vectors, Diagonalization of a matrix.

TOTAL: 42 Hrs.

COURSE OUTCOMES

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

CO1 : Understand the basic concepts of single variable calculus and matrices.
CO2 : Demonstrate basic matrix operations and determinants.
CO3 : Apply the concepts of calculus to find maxima, minima and area under the curve.
CO4 : Analyse the use of single variable calculus and matrices in biotechnology problems.
CO5 : Evaluate the determinant of different types of matrices, differentiation and integration of functions.
CO6 : Develop basic understanding of matrices and calculus in solving various biotechnology problems.

TEXT/REFERENCE BOOKS

1. B. S. Grewal, Elementary Engineering Mathematics, Khanna Publisher.
2. Seymour Lipschutz, Schaum's Outline of Calculus, Tata McGraw Hill.
4. Nita H. Shah, Foram A. Thakkar, Matrix and Determinant Fundamentals and Applications, CRC Press

24HS101T					English Communication					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand of the fundamental elements of communication in English language.
2. Correct expression in the English language at a basic level
3. Using appropriate vocabulary, grammar, effective paragraph construction, writing in day-to-day scenarios, including digital platforms
4. To learn and apply communication skills in different public and interpersonal contexts.

UNIT 1 INTRODUCTION TO COMMUNICATION **07 HRS.**

- The Fundamentals of Language and Communication
- Why English?
- Types of Communication
- Barriers to effective Communication
- Digital Communication

UNIT II: ENGLISH GRAMMAR AND VOCABULARY **07 Hrs.**

- Tenses, Articles, prepositions, active voice passive voice and concord
- Tools for vocabulary building
- Homophones, homonyms, one word substitution, antonyms, synonyms, Root Words, Prefixes and Suffixes, Connotations. Collocations, Idioms. phrases

UNIT III: RECEPTIVE SKILLS **07 Hrs.**

- Listening Skills: Difference between listening and hearing, Active listening and passive listening
- Types of listening, Traits of good listener
- Reading Skills: Why reading is important, Effective reading techniques, Speed Reading, The SQ3R Method

UNIT IV: COMPENDIUM SKILLS **07 Hrs.**

- Note Taking and Note Making: physical, digital, collective
- Summarizing
- Creating e-content

TOTAL: 28 Hrs.

COURSE OUTCOMES

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

CO1 : Demonstrate an understanding of the fundamentals of communication, including the basic components of the communication process and its significance in personal, academic, and professional contexts.

CO2 : Apply grammatical rules accurately in written and spoken communication to enhance clarity, coherence, and precision.

CO3 : Employ effective strategies for vocabulary development, such as word association, context clues, and mnemonic devices.

CO4 : Enhance their ability to identify and interpret implicit meanings, inference, and figurative language in both written and spoken texts, contributing to deeper comprehension and critical analysis.

CO5 : Develop strong written communication skills to effectively convey complex ideas and information in a clear, concise, and coherent manner within the compendium.

CO6 : Apply ethical communication principles and standards of academic integrity when creating and sharing compendiums and avoiding plagiarism.

TEXT/REFERENCE BOOKS

1. Effective Communication Skills. Kul Bhushan Kumar, Khanna Book Publishing, 2022.
2. Remedial English Grammar. F.T. Wood. Macmillan.2007
3. Sharma, Sangeeta and Binod Mishra. Communication Skills for Engineers and Scientists. New Delhi: PHI Learning Pvt. Ltd., 2009.
4. Kaul, Asha. Business Communication. Delhi: Prentice-Hall of India, 2006.

24CP101T					Computer Programming – I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
1	0	0	1	1	25	50	25	-	-	100

COURSE OBJECTIVES

1. To understand the usage of operators and data types.
2. To apply different types of Conditional and looping statement.
3. To create different types of data collections.
4. To implement user defined function.
5. To perform different operations upon files.

UNIT 1: Basics of Programming **3 Hrs.**

Introduction to Computer Programming, Features of C language, Structure of C program, program execution flow, C Tokens, variables, Data types, Operators, Decision control statements-if, switch, go to statement. Loop control structures- while, do-while, for loop, Break statement, Continue statement

UNIT 2: Derived Data types **4 Hrs.**

Array: one dimensional and multidimensional array, Declaration, initialization, Array Manipulations. Matrix operations, String-Basic Concepts, Inbuilt String manipulation Functions, Pointer, Pointer arithmetic, Pointer to pointer, Array of Pointers

UNIT 3: Functions and Structures **4 Hrs.**

Introduction to user defined functions, Types of Functions, Call by value-call by reference, recursion, pointers to functions, Structures, Array of Structure, Union

UNIT 4: Files Handling **3 Hrs.**

File handling in C, Different types of files, Operations on Files such as File creation, File deletion, File access modes such as read, write, append, File concatenation, File handling using seek function.

Total: 14 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand basics of programming.
CO2: Identify different programming constructs for a problem.
CO3: Apply appropriate derived data type for data storage.
CO4: Prepare a user defined data type based on data attributes.
CO5: Construct user defined functions for problem solving.
CO6: Analyse different data structure based on application requirement.

TEXT/REFERENCE BOOKS

1. Kernighan & Ritchie, C Programming Language, PHI
2. K. N. King , C Programming: A Modern Approach, W.W. Nortorn
3. David Griffiths and Dawn Griffiths, Head First C: A Brain-Friendly Guide, O'Reilly
4. E.Balaguruswamy, Programming in ANSI C, McGraw-Hill
5. Y.P. Kanetkar, Let us C, BPB Publication
6. Y.P. Kanetkar , Pointers in C, BPB Publications

24CP101P					Computer Programming Laboratory – I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To implement basic programming concepts.
2. To create different types of data collections.
3. To implement user defined function.
4. To perform different file handling operations.

List of Experiments:

1. **Introduction to Computer Programming**: Understanding compilation process through a simple C program, program execution flow, C Tokens, variables and keywords and identifiers, types of C constants and variables.

2. **Simple and formatted Input Output Operations:** Data types, Operators, Input /output statements in C, Formatted I/O, format specifiers, escaper sequences
3. **Decision making and branching:** if, if-else, if-else ladder, switch, go to statement, conditional operator statement

4. **Looping control structures:** while, do-while, for loop, Break statement, Continue statement
5. **Derived Data Type: Array and Strings:** One dimensional and multidimensional array, Declaration, initialization, Array Manipulations. Matrix operations, Basic Concepts, Inbuilt String manipulation with and without using inbuilt functions.
6. **Derived Data Type: Structure and Union:** structure, arrays and structures, structures and functions, pointer to structure, typedef, unions
7. **Functions:** Introduction to user defined functions, Types of Functions, Call by value-call by reference, header file creation, recursion, pointers to functions, arrays and functions
8. **Pointers:** Pointer's basics, use of &, * operator in context to pointers, Pointer arithmetic, Array and String processing using pointer, pointer to pointer, Array of Pointers
9. **File Handling in C:** File handling in C, Different types of files, Operations on Files, File handling functions.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Identify the use of appropriate naming conventions and programming style including appropriate comment density.
CO2: Implement a basic C program using appropriate control structure.
CO3: Apply appropriate derived data types based on data attributes.
CO4: Develop solutions with pointers and utilize them to access strings and structures.
CO5: Design user defined functions for problem solving and reuse them across different programs.
CO6: Apply suitable file handling functions and operations.

TEXT/REFERENCE BOOKS

1. Kernighan & Ritchie, C Programming Language, PHI.
2. K. N. King , C Programming: A Modern Approach, W.W. Norton.
3. E. Balaguruswamy, Programming in ANSI C, McGraw-Hill.
4. Y.P. Kanetkar,Let us C, BPB Publication.
5. Y.P. Kanetkar, Pointers in C, BPB Publication.

24CH101T					Engineering Chemistry					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To develop the fundamental understanding about traditional materials.
2. To provide the knowledge about structural features, synthesis, properties of various categories of advanced materials.
3. To develop the knowledge and skills for different characterization techniques of materials.
4. To provide the knowledge about the role of chemistry in modern engineering applications.

UNIT I: CHEMISTRY OF ENGINEERING MATERIALS **12 Hrs.**

Traditional Materials: Introduction and classification of materials; metallic materials, polymeric, ceramic materials Advanced Materials: Introduction to nanomaterials: Properties and application; Carbonaceous materials (fullerene, carbon nanotube, graphene, etc.); Composite materials; Liquid crystals: Classification and Application

UNIT II: MODERN ANALYTICAL TECHNIQUES **10 Hrs.**

Instrumentation, principle and characterization of materials: X-ray diffraction (XRD), Electro analytical techniques; FTIR, UV-visible spectroscopy; Thermal analysis (TGA-DTA-DSC); Chromatographic techniques (GC, HPLC)

UNIT III: ADSORPTION, CATALYSIS AND KINETICS **10 Hrs.**

Adsorption - Characteristics, Classification, Application , Adsorption isotherms- Freundlich, Langmuir & BET Chemical Kinetics - Rate law, Arrhenius equation, Transition state theory, Collision theory; Complex reactions Catalysis - Homogeneous and Heterogeneous Catalysis; Mechanism of Catalysis; Industrial Applications of catalysts

UNIT IV: CHEMISTRY OF ENERGY DEVICES **10 Hrs.**

Principles of primary and secondary batteries, Fuel Cells and their operation principles, Principles and uses of supercapacitors; Photocatalytic hydrogen production: Principles and challenges; Traditional and new generation solar cells.

TOTAL : 42 Hrs.

COURSE OUTCOMES

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

CO1 : **Remember** the structural features and properties of different classes of traditional materials
CO2 : **Classify** advanced materials like nanomaterials, carbonaceous and composite materials, and liquid crystals
CO3 : **Apply** the skills by understanding various instrumental techniques for characterisation of materials.
CO4 : **Analyze** the key concepts in engineering chemistry viz. adsorption and chemical kinetics and laterally ponder over the applications of such concepts in engineering challenges.
CO5 : **Justify** the important insights into the industrial application of different types of catalysis via analysing mechanisms of catalysis.
CO6 : **Develop** the knowledge on the role of chemistry in various modern engineering applications such as in energy devices.

TEXT/REFERENCE BOOKS

1. W.D. Callister, **"An Introduction to Materials Science & Engineering",** John Wiley & Sons (2007).
2. MW Barsoum, **"Fundamental of Ceramics",** IOP publishing (2003).
3. T. Pradeep, "Text book of Nanoscience and Nanotechnology", Mc. Graw Hill Education (2003).
4. Murty, Shankar, B Raj, Rath, Murday, **"Textbook of Nanoscience and Nanotechnology",** Springer (2013).
5. V. Raghavan, **"Materials Science and Engineering",** Prentice-Hall of India Private Limited (2003).
6. A. Douglas, Donald Skoog, M.West**, "Principles of Instrumental Analysis",** Cengage, 6th Edition, (2014)
7. Jain & Jain, **"Engineering Chemistry"** by Dhanpat Rai Publishing Company

24CH101P					Engineering Chemistry Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To enhance and develop scientific and analytical skills
2. To relate concepts learned in chemistry and engineering to the real-world situations.
3. To acquire skills to perform laboratory experiments.
4. To demonstrate safe and proper use of standard chemistry glassware and equipment.

LIST OF EXPERIMENTS

1 **Iodometry**– To determine the strength of given copper sulphate solution by titrating against N/20 sodium thiosulphate (hypo) solution
2 **Iodimetry**– To determine the strength of given ascorbic acid by titrating against standard N/10 iodine solution
3 **Complexometric Titration**– To determine the total, permanent and temporary hardness of given water by complexometric titration using standard 0.01M EDTA solution
4 **pH metric titration**– To determine the strength of given HCl solution using a standard NaOH solution by performing a pH-metric titration
5 **Conductometric titration**– To determine the strength of given HCl solution using a standard NaOH solution by performing a conductometric titration
6 **Chemical Kinetics**– To study the kinetics of decomposition of sodium thiosulphate by a mineral acid
7 **Drawing chemical structures** - To Draw Chemical Structures of organic molecules using ChemDraw
8 **Colorimetric determination**: To determine the concentration of copper present in the effluent of electroplating industries by using colorimeter.
9 **Detection of biomolecule**: Detection of the presence of carbohydrates in test solution by using Benedict's reagent
10 **Preparation of drug molecule**: Preparation of Aspirin from salicylic acid
11 **Polymerization**– To prepare a polymer (Nylon 6,10), identify the functional groups by FT-IR

COURSE OUTCOMES

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

CO1 : Recall the concepts learned in chemistry and engineering to the real-world situations.
CO2 : Show the ability to identify, analyse and interpret the results from the experiments.
CO3 : Experiment with the instrumental method using conductometer and pH meter.
CO4 : Analyse compounds by titrimetric, gravimetric and instrumental methods.
CO5 : Determine the concentration of unknown solutions by spectrophotometric method.
CO6 : Predict the reaction rate and predict the order and rate constant.

TEXT/REFERENCE BOOKS

1. V. K. Ahluwalia, S Dhingra, A. Gulati, College Practical Chemistry, Universities Press.
2. J.B. Baruah, P Gogoi, Foundations of Experimental Chemistry, PharmaMed Press.
3. S. S. Sawhney, M. S. Jassal, S.P. Mittal, A Text Book of Chemistry Practical, Vol. I & II, APH Publishing Corp.

24EE101T					Elements of Electrical and Electronics Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To impart knowledge on DC and AC circuits.
2. To learn construction, working principle and characteristics of transformer and induction machines.
3. To introduce students to various means for electrical safety, protection of electrical installations and Batteries
4. To understand rectification through p-n junction diode, applications of diode and Transistor Characteristics

UNIT I: BASICS OF ELECTRONICS **10 Hrs**

Semiconductor Diodes and Applications, Diode as a Switch, Diode as a Rectifier, Half Wave and Full Wave Rectifiers with and without Filters; Breakdown Mechanisms, Zener Diode – Operation and Applications; Opto-Electronic Devices–LEDs, Photo Diode and Applications; Silicon Controlled Rectifier (SCR) – Operation, Construction, Characteristics, Ratings, Applications.

Transistor Characteristics covering, Bipolar Junction Transistor (BJT) – Construction, Operation, Amplifying Action, Common Base, Common Emitter and Common Collector Configurations, Field Effect Transistor (FET) – Construction, Characteristics of Junction FET.

UNIT II: DC CIRCUITS **10 Hrs**

Electrical circuit elements (R, L and C), voltage and current sources, dependent and independent sources, Ohms Law, temperature co-efficient of resistance, Kirchhoff current and voltage laws, voltage and current divider circuit, Thevenin and Norton Theorems and their equivalents, maximum power transfer and superposition theorems, nodal and mesh analysis, star-delta transformation, Time domain analysis/natural response of first order RL and RC Circuit.

UNIT III: AC CIRCUITS **10 Hrs**

Generation of AC voltage, representation of sinusoidal waveforms, RMS values of different sinusoidal waveforms, Rectangular and Polar representation of phasor, Sinusoid representation in time and frequency domain, Analysis of single-phase ac series circuits consisting of R, L, C, RL, RC, RLC combinations, instantaneous power, average power and reactive power, complex power and power factor.AC parallel circuit and its solution in admittance form, resonance in AC series and parallel circuits, polyphase circuits, star and delta representation of polyphase circuits, power measurement in polyphase circuits.

UNIT IV: INTRODUCTION TO ELECTRICAL MACHINES AND ELECTRICAL INSTALLATION **12 Hrs**

Magnetic materials and its B-H characteristic, Faraday's Law of Electromagnetic Induction; **Single Phase Transformers:** Construction, working principle, types, EMF equation, ideal transformer, practical transformer, Operation of transformer on no-load and load, **Induction Machine:** construction, types of 3-phase induction motors, working principle, production of rotating magnetic field, operation, starting and running torques, Torque-slip characteristics, Power Stages in an induction motor.

Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing, Types of Batteries, Important Characteristics for Batteries. Elementary calculations for energy consumption, Electrical safety rules.

TOTAL : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Demonstrate application of different diodes in circuits and Understand the Transistor characteristics

CO2 – Understand electrical circuits using network theorems.

CO3 – Compare the behaviour of R, L and C and their combinations in AC circuits.

CO4 – Analyze balanced polyphase systems in star and delta configurations

CO5 – Understand the construction, working and basic characteristics of transformer and induction machines

CO6 -- Recognize the importance of protective devices, electrical safety measures and characteristics of Batteries

TEXT/REFERENCE BOOKS

1. J. Bird, **"Electrical Circuit Theory and Technology"**, Routledge, Tailor and Francis Group
2. D. P. Kothari and I. J. Nagrath, **"Basic Electrical Engineering"**, Tata McGraw Hill
3. B. L. Theraja, **"Electrical Technology",** Vol. 1, S. Chand Publication, New Delhi.
4. Surjit Singh, **"Electrical Estimating and Costing"**, Dhanpat Rai and Co.
5. Boylestad and Nashlesky, "**Electronic Devices and Circuit Theory**", PHI

24EE101P					Elements of Electrical and Electronics Engineering Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To gain practical knowledge on DC and AC circuits
2. To learn operation of electrical instruments and electrical machines
3. To introduce students to various means for electrical safety, protection of electrical installations
4. To understand characteristics and applications of semiconductor diodes and transistors.

LIST OF EXPERIMENTS

1. Introduction to elements of electrical engineering laboratory and to study different electrical measuring instruments.
2. To Verify Ohm's law with linear resistors and find power dissipation in resistor.
3. To validate Thevenin's and Norton theorem for DC circuits.
4. To validate Superposition and Maximum Power Transfer theorem for DC circuits.
5. To evaluate the AC R, L and R-L series circuit performance and to measure the active power, the reactive power and the apparent power connected with single phase AC supply.
6. To evaluate performance of AC R-L parallel circuit and to measure the active power, the Reactive power and the apparent power connected with single phase AC supply.
7. To perform a direct load test on a single-phase transformer and determine the efficiency and voltage regulation at different loads.
8. To measure three phase power using two wattmeter method.
9. To draw the time-current characteristics of MCB and study the function of ELCB.
10. To obtain the VI characteristic of silicon and germanium diodes.
11. To obtain reverse characteristics of Zener diode.
12. To study half wave, full wave and bridge rectifiers.
13. To determine the DC Characteristics of BJT in CE Configuration.
14. To study the types of batteries and their characteristics

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – To understand the basic operation of electrical equipment's & measuring instruments.
CO2 – To perform various network theorems for DC circuits.
CO3 – To understand the performance of AC circuit with R, L load.
CO4 – To evaluate star and delta configuration of polyphase system and measure power in polyphase system.
CO5 – To evaluate the performance of single phase transformer.
CO6 – To understand the working principle of semiconductor diodes, transistor characteristics and its applications.

24BT101T					Biological Systems for Engineers					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the importance of bioengineering principles, advanced biomedical technologies, and emerging trends in the field.
2. To introduce the students with an understanding of biodesign principles to create novel devices and structures.
3. To develop the skills necessary for to designing innovative solutions inspired by biological systems, such as mimicking organ functions for medical device development.
4. To evaluate the diagnostic capabilities and limitations of various imaging modalities and molecular diagnostic techniques.

UNIT I: INTRODUCTION TO BIOMOLECULES **7 Hrs.**

Cell as the basic unit of life, Overview of cell structure and functions. Carbohydrates: Properties and biological functions. Nucleic Acids: Structure and roles of DNA and RNA. Proteins: Structure, and its functions, Significance of lipids. Role of biomolecules: Characteristics and roles of enzymes, vitamins, and hormones.

UNIT II: INSPIRING BIOENGINEERING DESIGN **7 Hrs.**

Functions and classification of Nervous system. The brain functions as a central processing unit (CPU) system: Concepts of Artificial Neural Networks and Machine Learning techniques. The eye functions as a camera. The heart functions as a circulatory system. The ear and nose as signal transmission models. Electronic nose, Electronic tongue, Electronic skin. Lungs operate as an exchange model, and the kidneys function as a filtration system.

UNIT III: ADVANCED IMAGING & DIAGNOSTICS **7 Hrs.**

Introduction to Radiology- X Ray, Ultrasound, EEG, CT, PET, High-throughput diagnostics in clinics: Molecular Diagnostics: PCR, DNA chip, Diagnosis of genetic disorders.

UNIT IV: TRENDS IN BIOENGINEERING **7 Hrs.**

Stem cell and its applications, Bio printing techniques and materials. Applications of Bioinformatics: Artificial Intelligence for diagnosis and detection of communicable and non-communicable diseases, Biosensors in healthcare, Environmental monitoring.

TOTAL: 28 Hrs.

COURSE OUTCOMES

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

CO1 : Understand the fundamental principles of cellular biology, including the structure and functions of cells, genes, and biomolecules.
CO2 : Demonstrate the involvement of major organs and systems in the human body as models for
CO3 : Analyse the scope and opportunities of Implementing bioengineering concepts relates to advanced imaging and diagnostic techniques for clinical diagnosis and disease management.
CO4 : Get acquainted with concepts of bioengineering trends including biosensors, AI , Imaging techniques in disease diagnosis and treatment.
CO5 : Focus on implications of Bioinspired designs, Bioengineering trends including, tissue engineering and molecular diagnostics.
CO6 : Design and development of innovative solutions for healthcare, environmental monitoring, and biosecurity.

TEXT/REFERENCE BOOKS

1. Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M., **"Biology for Engineers**", Tata McGraw-Hill, New Delhi, 2012.
2. Arthur T. Johnson, **"Biology for Engineers"**, CRC Press, Taylor and Francis, 2011
3. Geoffrey M.Cooper**, "The Cell: A molecular approach"**, ASM Press, 2016.
4. Sohini Singh and Tanu Allen, **"Biology for Engineers"**, Vayu Education of India, New Delhi, 2014.
5. Yoseph Bar-Cohen, **"Biomimetics: Nature-Based Innovation**" , 1st edition, 2012, CRC Press
6. Stuart Fox, Krista Rompolski, McGraw-Hill, "**Human Physiology"**, eBook. 16th Edition, 2022
7. D. Floreano and C. Mattiussi, **Bio-Inspired Artificial Intelligence: Theories, Methods and Technologies**, MIT Press, 2008

24BT102T					Biology For Engineers					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the basic biological concepts and their engineering applications.
2. To introduce the students with an understanding of biodesign principles to create novel devices and structures.
3. To provide the students an appreciation of how biological systems can be re-designed as substitute products for natural systems.
4. To study the development of interdisciplinary vision of biological engineering.

UNIT I: INTRODUCTION TO BIOMOLECULES **7 Hrs.**

Cell as the basic unit of life, Overview of cell structure and functions. Carbohydrates: Properties and biological functions. Nucleic Acids: Structure and roles of DNA and RNA. Proteins: Structure, and its functions, Significance of lipids. Role of biomolecules: Characteristics and roles of enzymes, vitamins, and hormones.

UNIT II: NATURE-BIOINSPIRED MATERIALS AND MECHANISMS (QUALITATIVE) **7 Hrs.**

Echolocation (ultrasonography, sonars), Photosynthesis (photovoltaic cells, bionic leaf). Bird flying (GPS and aircrafts), Lotus leaf effect (Super hydrophobic and self-cleaning surfaces), Plant burrs (Velcro), Shark skin (Friction reducing swim suits), Kingfisher beak (Bullet train). Human Blood substitutes- hemoglobin-based oxygen carriers (HBOCs) and perflourocarbons (PFCs).

UNIT III: ENGINEERING PERSPECTIVES OF BIOLOGICAL SCIENCES **7 Hrs.**

Biology and engineering crosstalk –Hybridoma technology, Plant Tissue Culture, Animal Tissue Culture; Tissue Engineering, Introduction to Biomimetics and Biomimicry, Nanobiotechnology, Introduction to Radiology, High-throughput diagnostics in clinics, Bioprocessing and Biomaterials.

UNIT IV: TRENDS IN BIOENGINEERING **7 Hrs.**

Stem cell and its applications, Bio printing techniques and materials. Applications of Bioinformatics, Artificial Intelligence for diagnosis and detection of communicable and non-communicable diseases, Biosensors in healthcare, Environmental monitoring.

TOTAL: 28 Hrs.

COURSE OUTCOMES

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

CO1 : Gain fundamental knowledge of origin of life.
CO2 : Explain the functions of cell and its components.
CO3 : Evaluate the principles of design and development, for exploring novel bioengineering projects.
CO4 : Compare biology with engineering
CO5 : Corroborate the concepts of biomimetic for specific requirements
CO6 : Think critically towards exploring innovative biobased solutions for socially relevant problems.

TEXT/REFERENCE BOOKS

1. Thyagarajan S., Selvamurugan N., Rajesh M.P., Nazeer R.A., Thilagaraj W., Barathi S., and Jaganthan M., **"Biology for Engineers**", Tata McGraw-Hill, New Delhi, 2012.
2. Arthur T. Johnson, **"Biology for Engineers"**, CRC Press, Taylor and Francis, 2011
3. Geoffrey M.Cooper**, "The Cell: A molecular approach"**, ASM Press, 2007.
4. Sohini Singh and Tanu Allen, **"Biology for Engineers"**, Vayu Education of India, New Delhi, 2014.
5. Yoseph Bar-Cohen, **"Biomimetics: Nature-Based Innovation**" , 1st edition, 2012, CRC Press.

24HS104T					Organizational Behaviour					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
1	0	0	1	1	25	50	25	--	--	100

COURSE OBJECTIVES

1. To enable the development of a perspective to diagnose & efficiently deal with matters of human behaviour in organisations
2. To enrich understanding of the dynamics of interaction and integration between the individual and the organization.
3. To explore the organization system in entirety to capture the full complexity of organizational behaviour.
4. Critically appraise the potential effects of important developments in the external environment on organizational behaviour

UNIT 1 INTRODUCTION TO ORGANIZATIONAL BEHAVIOUR **04 HRS.**

Definition and scope of organization, behaviour, and organizational behaviour, Historical developments and emerging concerns in OB, Perception in organizational behaviour: elements, principles, and biases, Learning theories, conditioning, application in organizations, Personality theories, Attitudes in the workplace.

UNIT II: EMOTIONS, STRESS MANAGEMENT, GROUP DYNAMICS AND INTERPERSONAL RELATIONSHIPS **04 Hrs.**

Understanding emotions in organizational behaviour, Emotional labor, Stress management techniques in organizational settings, Group formation and dynamics in organizations, Group decision-making techniques and their application, Team building strategies and effective communication, Influence, power dynamics, and organizational politics

UNIT III: LEADERSHIP AND ORGANIZATIONAL CULTURE **03 Hrs.**

Leadership theories: overview and application in organizational settings, Leadership styles and their impact on organizational behaviour, Understanding organizational culture and climate

UNIT IV: ORGANIZATIONAL CHANGE AND STRUCTURE, BALANCING WORK AND LIFE **03 Hrs.**

Organizational change processes, Resistance management during organizational change, Organizational structure and design, Job satisfaction: determinants and impact on employee behaviour, Stress prevention and management techniques, Work-life balance strategies and their role in organizational behaviour

TOTAL: 14 Hrs.

COURSE OUTCOMES

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

CO1 : Critically gage the potential effects of important developments in the external environment on organizational behaviour.
CO2 : Analyze organizational behavioural issues in the context of organizational behaviour theories, models, and concepts.
CO3 : Analyze the behaviour of individuals and groups in organizations in terms of the crucial factors that effect organization behaviour.
CO4 : Analyze organizational behavioural matters in the context of organizational behaviour theories, models, and concepts.
CO5 : Demonstrate how the organizational behaviour can integrate in understanding the motivation (why) behind behaviour of people in the organization.
CO6 : Manage conflict in organizational context and deal with stress.

TEXT/REFERENCE BOOKS

1. Fiona M. Wilson, Organizational Behaviour and Work, Oxford University Press, 5th Edition, 2018.
2. Stephen P. Robbins, Timothy A. Judge, Neharika Vohra, Organization Behaviour, Pearson Education, 18th Edition, 2019.
3. Ashwathappa, K., Organizational Behaviour, Himalaya Publication, 12th Edition 2019.
4. wathappa, K., Organizational Behaviour, Himalaya Publication, 12th Edition 2019.

24YOG101					Yoga, Health & Hygiene					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To impart the students with the basic concepts of physical education, sports, and yoga for health and wellness.
2. To familiarize the students with health-related exercises, sports, and yoga for overall growth and development.
3. To create a foundation for professionals in physical education, sports, and yoga.
4. To impart the basic knowledge and skills to teach physical education, sports, and yoga activities.

ACTIVITY I: KINESIOLOGY AND CARDIO FITNESS TEST

Introduction to Kinesiology and the Physiological Basis of Conditioning, Sports Psychology, and the Cooer Cardio Fitness Test 12-Minutes Run/Walk: How to Start Walking/Runing: Get expert tips, tools, and training.

ACTIVITY II: YOGA

Introduction to Yogasana and Yoga Therapy: A Rehabilitation Tool and the Effect of Yoga on Exercise Endurance as Assessed by Cardiorespiratory Efficiency Tests: Studt on yogic practices that promote and improve respiratory and cardiovascular function and enhance physical fitness.

ACTIVITY III:GAMES AND SPORTS LEAGUE

Practice sessions for outdoor and indoor games, event-wise practice, and team games organized on the sport, game-wise practice as per the student's interest: Football, Chess, Cricket, Tennis, Basketball, Volleyball, Athletics (Relay), Pickleball.

COURSE OUTCOMES

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

CO1 : Discover the balance of health and happiness through the basic principles and practices of physical education, sports, and yoga.
CO2 : Understand that the students will be able to be instructed on physical activities, sports, yoga practices, theories, and rules of various games for healthy living.
CO3 : Analyze emerging trends and issues in world sports and develop leadership qualities among students to conduct, organize, and officiate physical education, sports, and yoga events at schools, colleges, and the community.
CO4 : Practice on the field and in the indoor yoga hall.
CO5 : Develop a spirit of teamwork and fair play.
CO6 : Demonstrate understanding by participating in games and sports leagues.

TEXT/REFERENCE BOOKS

1. Athletic Track and Court Marking Handbook of Games And Sports – Rajesh Agola.
2. Asana, Pranayama, and Kriyas - Swami Satyanand Swami.Munger.
3. Sports Games and Rule, Regulation - Pankaj Vinayak Pathak
4. Yogic Prakriyanche Margdarshan – Dr.M.L.Gharote - (The Lonavala Yoga Research Institute,Lonavala)

24NSS101					National Service Scheme (NSS)					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To develop a sense of civic and social responcibility.
2. To identify the needs and problems of the community and involve them in problem-solving.
3. To engage in creative and constructive social action.
4. To develop social character and leadership through NSS.

ACTIVITY I: ENVIRONMENT AND SUSTAINABILITY -WATER - WAST MANAGEMENT

Volunteering work for Environment & Sustainability (water and waste management) and Tree Plantation.

ACTIVITY II: NSS 7 DAYS SPECIAL CAMP

Volunteering for tree planting, agriculture compost, tree guard,Gujarat Skill Development Mission, and social activities in the village as per the government NSS manual.

ACTIVITY III: FIT INDIA MISSION

Volunteering for Cardio Fitness, Yoga, Running, Mission Olympics, Self-Defense, and Agneepath Mission.

COURSE OUTCOMES

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

CO1 : Identify the needs and problems of the community.
CO2 : Understand the importance of his / her responsibilities towards society.
CO3 : Analyze the environmental and societal problems/issues.
CO4 : Evaluate the existing system and propose practical solutions for the sustainable development.
CO5 : Develop a government or self-driven projects effectively in the field.
CO6 : Understand the government or self-driven projects effectively in the society.

TEXT/REFERENCE BOOKS

1. NSS Course Manual, Published by NSS Unit,PDEU (https://www.pdpu.ac.in/nssreport.html)
2. Government of Gujarat NSS Cell (https://nss.gov.in/gujarat-1)
3. Government of India NSS Cell, Activities reports and manual (https://nss.gov.in/)

24NCC101					National Cadet Corps (NCC)					
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 discipline, character, brotherhood, the spirit of adventure and ideals of selfless service amongst young students
2. To develop youth leadership qualities in the students.
3. To induce social consciousness among students through various NCC camps

ACTIVITY I: INTRODUCTION TO NCC

Introduction to NCC, aims and objectives, structure and organization of NCC, cardinals of NCC, NCC Flag, oath of NCC, NCC Song, incentives of NCC

ACTIVITY II: NATIONAL INTEGRATION

Importance of national integration and awareness, necessity, national interests, objectives, threats and opportunities, unity in diversity

ACTIVITY III: NCC CAMPS, SOCIAL SERVICE, AWARENESS AND COMMUNITY DEVELOPMENT ACTIVITIES

Social awareness & community development, health & hygiene, environment awareness and conservation, cadets will participate in various activities e.g., blood donation camp, swachhata abhiyan, constitution day, etc., participation into NCC camps like ATC, CATC, NIC, COC, TSC, RDC, leadership camps, etc.

ACTIVITY IV: DRILL, WEAPON TRAINING AND ADVENTURE ACTIVITIES

Types of drill, foot drill, general and words of command, saluting, weapon training, map reading, field craft & battle craft, Introduction to infantry weapons & equipment, obstacle and weapon training (during camps), adventure training, participation into Republic and Independence day ceremonial parades at university.

COURSE OUTCOMES

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

CO1 : Know about the history of NCC, its organization, and incentives of NCC for their career prospects.
CO2 : Understand the importance of Nation building and individual contribution to the same
CO3 : Maintain discipline and team spirit
CO4 : Build the character and leadership qualities
CO5 : Understand that drill as the foundation for discipline and to command a group for common goal.
CO6 : Develop the sense of self-less social service for better social & community life.

TEXT/REFERENCE BOOKS

1. Cadet's Handbook SD/SW- Common Subjects, all wings by DG NCC, New Delhi

B. Tech. Semester 2
Group 2

1. **Electronics and Communication Engineering**
2. **Civil Engineering**
3. **Mechanical Engineering**
4. **Chemical Engineering**
5. **Biotechnology**

Course Name	Course Code	Th	Tut	Pra	Hrs	Cr
24HS105T	Professional Communication	2	0	0	2	2
24MA103T	Mathematics - II	3	1	0	4	4
24MA104T	Mathematics for Biotechnology – II (Applicable for Biotechnology Only)					
24CP102T	Computer Programming – II	1	0	0	1	1
24CP102P	Computer Programming Laboratory – II	0	0	2	2	1
24PH101T	Applied Physics (Only For ECE)	3	0	0	3	3
24PH102T	Engineering Physics (Only For Mechanical and Civil)					
24PH103T	Modern Physics (Only For Biotechnology and Chemical)					
24PH101P	Applied Physics Laboratory (Only For ECE)	0	0	2	2	1
24PH102P	Engineering Physics Laboratory (Only For Mechanical and Civil)					
24PH103P	Modern Physics Laboratory (Only For Biotechnology and Chemical)					
24ME101P	Workshop Practices	0	0	2	2	1
24ME102P	Engineering Graphics	0	0	4	4	2
24CV101T	Environmental Science	2	0	0	2	2
24HS102T	Universal Human Values	1	0	0	1	1
24HS103T	Indian Knowledge System	2	0	0	2	2
		14	**1**	**10**	**25**	**20**

24HS105T					Professional Communication					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To strengthen the communication skills of professionals to make them ready for the modern workplace.
2. To fine tune their professional skills and expertise using communication skills.
3. To participate in the life-long learning process with confidence and certainty.
4. To develop analytical, research, and organizational skills through communication skills for a fulfilling career.

UNIT 1 TECHNICAL WRITING **07 HRS.**

- E-mails
- Report Writing
- Proposal writing (Project, Research and Business)
- Review Writing (Books and Articles)

UNIT II: ORATORY SKILLS **07 Hrs.**

- Art of Introducing oneself
- Presentation Skills
- Public speaking

UNIT III: EMPLOYABILITY SKILLS **07 Hrs.**

- Deciphering JD (Job Descriptions)
- Cover Letter Drafting
- Resume Writing
- Group Discussion
- Interview Skills

UNIT IV: ADVANCED READING AND CRITICAL THINKING **07 Hrs.**

- Critical Thinking
- Language and Communication:
- Ethical Considerations:
- Interdisciplinary Perspective:
- Communication Skills:
- Philosophy of Science

TOTAL: 28 Hrs.

COURSE OUTCOMES

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

CO1 : Develop the technical writing skills essential for effective communication in professional settings, including business environments, academic institutions, and research organizations.

CO2 : Master the art of public speaking by delivering clear, engaging, and persuasive presentations to diverse audiences, demonstrating confidence, poise, and effective communication techniques.

CO3 : Demonstrate the ability to decipher job descriptions, extracting key requirements, and qualifications to align their skills and experiences effectively.

CO4 : Effectively prepare for and participate in group discussions, demonstrating active listening, critical thinking, and the ability to articulate ideas coherently and persuasively.

CO5 : Understand the importance of clear, honest communication in engineering practice and ethical decision-making in upholding privacy rights and societal well-being.

CO6 : Explore interdisciplinary approaches to problem-solving.

TEXT/REFERENCE BOOKS

1. Effective Communication Skills. Kul Bhushan Kumar, Khanna Book Publishing, 2022.
2. Remedial English Grammar. F.T. Wood. Macmillan.2007
3. Sharma, Sangeeta and Binod Mishra. Communication Skills for Engineers and Scientists. New Delhi: PHI Learning Pvt. Ltd., 2009.
4. Kaul, Asha. Business Communication. Delhi: Prentice-Hall of India, 2006.

24MA103T					Mathematics – II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs. / Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand and apply principles of complex differentiation and integration effectively.
2. Solve systems, find eigenvalues, and apply transformations confidently.
3. Solve various ODEs, apply methods, and tackle engineering problems.
4. Analyze periodic functions, derive series, and apply in diverse applications.

UNIT 1 COMPLEX DIFFERENTIATION AND INTEGRATION **12 Hrs.**

Limit, Continuity, Differentiability of the function of a complex variable, Analytic function, Cauchy-Riemann equation (in Cartesian coordinates), Harmonic function and its significance, Singularities, Definition of a Complex line integral, Contour integrals, Cauchy integral theorem, Cauchy Integral formula (CIF), CIF for derivatives, Taylor's series and Laurent Series , Calculation of residues, Cauchy Residue theorem, Applications of residues to evaluate real definite integrals.

UNIT 2 MATRIX ALGEBRA AND ITS APPLICATIONS **10 Hrs.**

Solution of system of algebraic equation - Rank of a matrix, consistency of system of equation - Characteristic equation of a square matrix- Eigen values and Eigenvectors of a real matrix - Properties of Eigen values and Eigen vectors - Cayley-Hamilton theorem (without proof) - finding inverse of a matrix - Diagonalization of a matrix.

UNIT 3 ORDINARY DIFFERENTIAL EQUATIONS WITH APPLICATIONS **10 Hrs.**

Differential equations of Higher-order differential equations with constant coefficients, Rules for finding C.F. and P.I., Method of variation of parameters, Cauchy and Legendre's linear equations, Linear differential equations of second order with variable coefficients; Simultaneous linear equations with constant coefficients, applications of higher-order differential equations in solving engineering problems.

UNIT 4 FOURIER SERIES **10 Hrs.**

Periodic functions, Odd and even functions, Euler's formulae for Fourier series in an interval of length 2 pi, Change of interval, Dirichlet's conditions, Half range Sine and Cosine series, Complex Fourier series, Parseval's identity and its applications.

TOTAL: 42 Hrs.

COURSE OUTCOMES

On completion of the course, students will be able to

CO1 : Recall fundamental concepts of complex differentiation, matrix algebra, differential equations, and Fourier series.

CO2 : Understand the significance of complex differentiation, integration, Matrix, ODE and Fourier series in respective contexts.

CO3 : Apply the concept of complex function, Matrix, ODE and Fourier series to extract the solutions of engineering problems

CO4 : Analyze the use of complex variable Matrix, ODE and Fourier series in engineering problems.

CO5 : Assess the significance and effectiveness of mathematical concepts and theorems in solving real-world problems, particularly in engineering and scientific applications.

CO6 : Design and construct solutions to complex mathematical problems using a variety of techniques, including transformations, mappings, and advanced methods in differential equations.

TEXT/REFERENCE BOOKS

1. R.V. Churchill and J. W. Brown, Complex variables and Applications, McGraw-Hill.
2. J. M. Howie, Complex Analysis, Springer-Verlag.
3. R. K. Jain and S. R. K. Iyengar, Advanced Engineering Mathematics, Alpha Science.
4. Erwin Kreyszig, Advanced Engineering Mathematics", John Wiley.
5. G. Strang, Linear Algebra and its Applications, Cengage Learning.
6. K. Hoffman and R. A. Kunze, Linear Algebra", Prentice Hall of India.

24MA104T					Mathematics for Biotechnology – II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. To make students acquainted with the basics of functions of several variables.
2. To be able to formulate and solve various biotechnology problems using the methods of solving ODEs.
3. To study the use for double and triple integral to find area and volume.
4. To be able to evaluate problems related to probability and distribution.

UNIT I: FUNCTIONS OF SEVERAL VARIABLES **10 Hrs.**

Functions of two variables, Limits and Continuity, Partial derivatives, Total derivatives, Maxima and minima, Lagrange multipliers method.

UNIT II: MULTIPLE INTEGRALS **12 Hrs.**

Definition Evaluation of double integral (Cartesian – Polar form), Change of orders, Change of variables, Evaluation of triple integral, change of variables (Cartesian to spherical – and cylindrical), Applications, Area, Volume.

UNIT III: ORDINARY DIFFERENTIAL EQUATIONS **10 Hrs.**

Differential equations of first order and first degree, Exact differential equations, Integrating factors, Higher order differential equations with constant coefficients, Rules for finding C.F. and P.I., Cauchy and Legendre's linear equations, Applications of higher order differential equations in solving biotechnology problems.

10 Hrs.

UNIT IV: PROBABILITY AND DISTRIBUTION

Sample Space and Events; Axioms, Interpretations and Properties of Probability; Expectation; conditional Probability; Total probability, Bayes' Rule, Random variables; Measures of central tendency and dispersion.

Total: 42 Hrs.

COURSE OUTCOMES

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

CO1 : Understand the basic concepts of multivariable calculus, and differential equations.
CO2 : Demonstrate the use of multivariable calculus, differential equations.
CO3 : Apply appropriate tool/method to extract the solutions of biotechnology problems.
CO4 : Analyze the obtained solution in context with theory.
CO5 : Evaluate area, volume using multiple integrals.
CO6 : Create a mathematical model of biotechnology interest.

TEXT/REFERENCE BOOKS

1. B. S. Grewal, Elementary Engineering Mathematics, Khanna Publisher.
2. M. D. Raisinghania, Ordinary and partial differential equations, S Chand Publication.
3. S. C. Gupta and V. K. Kapoor, Fundamental of Mathematical Statistics, S. Chand and Sons
4. Sheldon M. Ross, Introduction to probability and statistics for engineers and scientists, Academic Press publication.

24CP102T					Computer Programming – II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
1	0	0	1	1	25	50	25	-	-	100

COURSE OBJECTIVES

1. To impart the basic concepts of Python Programming language
2. To be familiar with data structures available in Python.
3. To understand the concept of function & object-oriented programming.
4. To use the file and exception handling for designing applications

UNIT 1 INTRODUCTION AND LANGAUGE FUNDAMENTALS **4 Hrs.**

Definition and its historical background, Comparison with other programming languages. Python IDEs **Tokens:** Identifiers, Keyword **Data Types:** Int, Float, Bool, Complex, Str, List, Tuple, Dictionary and Set, Type conversion, Concept of mutability, immutability and reusability **Operators:** Arithmetic, Relational, Logical, Identity and Membership, Input and Output methods Control Flow Conditional statements: If, elif and else, nesting, Iterative or loop statement: for, while, for else and while else, Transfer statements: break, continue, pass.

UNIT 2 FUNCTIONS **3 Hrs.**

Function Declaration and calling, Types of Function arguments, scope of variable, Recursive function Recursive function **Types of function:** Anonymous or lambda, Map, Filter, Reduce, Function aliasing, Nested function, Decorator function, Decorator chaining Generator function

UNIT 3 OBJECT ORIENTED PROGRAMMING **4 Hrs.**

Class, Object, Object reference, Constructor and self-variable, Types of variables, Types of method, Destructor, Composition, Aggregation, Inheritance, Polymorphism, Abstract classes.

UNIT 4 FILE AND EXCEPTION HANDLING **3 Hrs.**

File handling Types of files, writing and reading with text file, important functions of file handling, working with directories, CSV file handling, pickling and unpickling **Exception Handling** exceptions handling using try-except blocks. Raising exceptions and custom exception classes.

14 Hrs.

COURSE OUTCOMES

CO1- Understand the basic concepts of programming with python.
CO2- Demonstrate proficiency in using different data types, operators, and control structures in Python programs.
CO3- Demonstrate the usage of both built-in and user-defined functions
CO4- Define and use classes in Python to represent attributes and methods, and demonstrate composition, aggregation, inheritance and polymorphism.
CO5- Implement exception handling mechanisms to deal with errors.
CO6- Demonstrate file operations and exception handling.

TEXT/REFERENCE BOOKS

1. John V Guttag, Introduction to Computation and Programming Using Python, Prentice Hall of India.
2. Allen Downey, Jeffrey Elkner and Chris Meyers, How to think like a Computer Scientist, Learning with Python, Green Tea Press.
3. Al Sweigart, Automate the Boring Stuff with Python
4. Martin C. Brown, Python: The Complete Reference, Osborne, McGraw-Hill
5. R. Nageswara Rao, Core Python Programming, Dreamtech Press

24CP102P					Computer Programming Laboratory – II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To impart the basic concepts of Python programming language
2. To be familiar with data structures available in Python.
3. To understand the concept of function & object-oriented programming.
4. To use file and exception handling for designing applications

List of Experiments:

1. **Language fundamentals**:
   Understanding interpretation, program execution flow, tokens, variables and keywords and identifiers, constants and variables
2. **Input Output Operations:**
   Basic data types, mutability, immutability, Operators, Input /output statements, format specifiers, escape sequences
3. **Decision making, Looping control structures**
   If, elif and else, nesting, Iterative or loop statement: for, while, for else and while else, Transfer statements: break,
4. **Advanced datatypes**
   String, List, Tuples, Dictionary, Set
5. **Functions:**
   Basics of functions, types of arguments
6. **Types of functions**
   Anonymous function, function aliasing, nested function, decorator function and generator function
7. **Object Oriented programming**
   class, object, types of variable and methods, composition, aggregation, inheritance, types of inheritance
8. **File Handling:**
   writing and reading with text file and csv file, working with directories, pickling and unpickling

COURSE OUTCOMES

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

CO1- Apply the concepts of variables, decision making and looping with python.
CO2- Apply various data structures available in Python to solve computational problems.
CO3- Implement advanced function concepts such as decorator chaining and generator functions.
CO4- Design and implement object-oriented solutions to programming problems using composition, aggregation, inheritance and polymorphism.
CO5- Develop Python scripts, for file handling tasks.
CO6- Create and manage files in python.

TEXT/REFERENCE BOOKS

1. John V Guttag. “Introduction to Computation and Programming Using Python”, Prentice Hall of India.
2. Allen Downey, Jeffrey Elkner and Chris Meyers "How to think like a Computer Scientist, Learning with Python", Green Tea Press.
3. Al Sweigart, “Automate the Boring Stuff with Python”
4. Martin C. Brown, “Python: The Complete Reference, Osborne, McGraw-Hill
5. R. Nageswara Rao, “Core Python Programming”, Dreamtech Press

24PH101T					Applied Physics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understand Electric and Magnetic Fields, applying vector algebra.
2. Apply Maxwell's equations to analyse electromagnetic waves and transmission.
3. Analyse semiconductor behaviour and its applications in electronic devices
4. Evaluate optical phenomena and their engineering applications in communications.

UNIT I: ELECTRICITY AND MAGNETISM **12 Hrs.**

Vector Algebra, Fundamental theorems of Gradient, Curls, and Divergence, Curvilinear co-ordinates, Continuous charge distribution, Divergence and Curl of Electrostatic Field, Electric potential and its applications, Work and Energy in Electrostatic, Bio-Savart's law, Divergence and curl of magnetic fields, Vector Potential, Ohm's law, EMF, Faraday's law of electromagnetic induction, Energy in Magnetic Fields, Maxwell's correction to ampere's law and Maxwell's equations, Poynting Vector.

UNIT II: ELECTROMAGNETIC WAVES **10 Hrs.**

Waves equation, Reflection and Transmission of waves, Polarisation, Wave equation for E and B for monochromatic plane waves, Propagation in linear media, reflection and transmission in normal and oblique incidence, Electromagnetic waves in conductors, Frequency dependence of permittivity, Waveguides, TE waves in rectangular waveguide, The Coaxial transmission line.

UNIT III: PHYSICS OF SOLIDS **10 Hrs.**

Fermi electron gas, Fermi level and surface, Energy bands, Energy Gap, Energy and band structure of conductor, insulators and semiconductors, Intrinsic semiconductors at 0K and room temperature, Intrinsic conductivity, Types of semiconductors, doping impurities, Temperature variation of carrier concentration, Electrical conductivity in semiconductors, Hall Effect, and magnetic materials

UNIT IV: OPTICS **10 Hrs.**

Nature of light waves, Fermat's principle, Coherent Sources, Interference, Two source interference, Interference in thin films, Newton's ring, Fresnel and Fraunhofer diffraction, Diffraction from single slit and double slit, Lasers, optical fibres and Holography, Applied optics: engineering measurements.

TOTAL: 42 Hrs.

COURSE OUTCOMES

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

CO1 : Recall fundamental laws and principles of electromagnetism and optics.
CO2 : Explain concepts of waves, conductivity, and semiconductor properties.
CO3 : Utilize principles to solve problems in electricity, magnetism, and optics.
CO4 : Evaluate electromagnetic phenomena and semiconductor behaviour through experimentation.
CO5 : Assess the effectiveness of engineering design for electromagnetic and optical devices.
CO6 : Design solutions for engineering challenges involving electromagnetics and semiconductors.

TEXT/REFERENCE BOOKS

1. Griffith, D. J., Introduction to Electrodynamics, Prentice Hall.
2. M. N. Avadhanulu and P G Kshirsagar, A text book of Engineering Physics, S.Chand Publications.
3. Sears and Zemansky, University physics, Pearson publications.
4. Principles of Electromagnetics, Matthew N. O. Sadiku, Oxford publications.
5. Hecht, E., Optics, Pearson Education.
6. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa Publishing House Pvt. Ltd.-New Delhi.

24PH101P					Applied Physics Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. Understand principles of electromagnetism and their experimental applications.
2. Analyse experimental setups and procedures related to electricity and magnetism.
3. Apply concepts of electromagnetic phenomena and optics in practical experiments.
4. Investigate semiconductor device electrical properties through experimentation.

LIST OF EXPERIMENTS

1 To determine e/m using Thomson's method.
2 To study Bio-Savart's Law.
3 To verify Faraday and Lenz's law.
4 To study the magnetic field along the axis of a coil
5 To determine the electrical conductivity of metals.
6 To study the characteristics of Si solar cells.
7 To study the phenomenon of photoconductivity using CdS photo-resistor.
8 To determine energy band gap of semiconductor using four probe method.
9 To study the hall effect and determine hall voltage, hall coefficient, type of majority charge carriers, carrier concentration and hall angle.
10 To study of the ferromagnetic hysteresis.
11 To determine the wavelength of monochromatic light (sodium light) using Newton's rings.
12 To measure the slit width of single, blade and double slits.
13 To understand fundamental of optical fibres and analogue optical fibre communication.

COURSE OUTCOMES

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

CO1 : Recognize electromagnetic principles and practical applications in experimental setup.
CO2 : Interpret experimental setups and procedures for electricity, magnetism, and optics.
CO3 : Demonstrate and implement the concepts of electromagnetic phenomena and optics.
CO4 : Investigate the electrical properties of semiconductor device.
CO5 : Examine the experimental data to identify trends and physical relationships.
CO6 : Design experiments to investigate electromagnetism and semiconductor properties.

TEXT/REFERENCE BOOKS

1. Griffith, D. J., Introduction to Electrodynamics, Prentice Hall.
2. M. N. Avadhanulu and P G Kshirsagar, A text book of Engineering Physics, S. Chand Publications.
3. Sears and Zemansky, University physics, Pearson publications.
4. Principles of Electromagnetics, Matthew N. O. Sadiku, Oxford publications.
5. Hecht, E., Optics, Pearson Education.
6. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa Publishing House Pvt. Ltd.-New Delhi.

24PH103T					Modern Physics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. Understanding concepts of modern physics.
2. Explaining the physics of EM waves and its propagation.
3. Applying the Acquired basic knowledge of solid state physics.
4. Analyze the Concepts of nuclear radiation physics.
5. Estimate and correlate the concepts learned so far for various engineering applications.
6. Apply the fundamentals designs of modern physics to solve complex physical problems.

UNIT I: MODERN PHYSICS **09 Hrs.**

Review of quantum concepts: particle nature of light, photoelectric effect, Compton effect, matter waves, wave packets, phase and group velocity, Interference, Diffraction and Polarization, Engineering Physics related applications. Davisson Germer experiment, Heisenberg uncertainty principle.

UNIT II: ELECTROMAGNETIC WAVES **12 Hrs.**

Physical and mathematical concepts of gradient, divergence and curl, Gauss theorem, applications in gravitation and electrostatics. Stokes' theorem and engineering Physics related applications. Equation of continuity, Biot Savart law – Ampere's law – magnetization and magnetic intensity, Faraday's law of Maxwell's equations, wave equation for electromagnetic radiation, applications of optical fibers in communication.

UNIT III: SOLID STATE PHYSICS **12 Hrs.**

Crystalline and Amorphous Solids, Ionic Crystals, Covalent Crystals, Van der Waals Bond, Band Theory of Solids, Semiconductor Devices, Electrical conductivity, Resistivity, Magnetism, Superconductivity, Introduction to BCS Theory.
Concepts of LASER, Interaction of radiation of matter-quantum mechanical view, characteristics and Types of laser, Engineering Physics related application of lasers.

UNIT IV: NUCLEAR RADIATION PHYSICS **09 Hrs.**

Mass defect, binding energy, Radioactivity, Types of Radiation, Interaction of Radiation with matter, Radiation detector, nuclear reactions, elements of nuclear reactors, fission and fusion, Engineering Physics related problems.

TOTAL: 42 Hrs.

COURSE OUTCOMES

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

CO1 : To relate to shape the engineering perspective in the student mind.
CO2 : Aims to provide an understanding to analyse the physical phenomena of various physics concepts.
CO3 : To develop an analytical perspective in the student.
CO4 : To enable understanding in the students the importance of application of already studied topics.
CO5 : To explain and relate the importance of interdisciplinary problems.
CO6 : To strengthen problem solving attitude in physics using mathematical tools.

TEXT/REFERENCE BOOKS

1. Resnick, Halliday and Krane, Physics part I and II, John Wiely
2. Ghatak, Optics, Tata McGraw Hill
3. Purcell E.M. Electricity and Magnetism - Berkeley Physics Course, Vol.2, Tata McGraw-Hill.
4. Kittel C., Knight W.O. and Ruderman M.A., Mechanics - Berkeley Physics Course, Tata McGraw-Hill.
5. Griffith D.J.H., Introduction to Electrodynamics - Prentice Hall, India.
6. M. N. Avadhanulu, A text book of engineering Physics, S. Chand & Company, Ltd.
7. Feyman R.P., Leighton R.B. and Sands M. The Feyman Lectures on Physics, Vol. 1., Narosa Publication.

24PH103P					Modern Physics Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. Understand the characteristics of waves, semiconductor, heat pump, LASER.
2. Enhance knowledge on application of physics in engineering
3. To develop intellectual communication skills and discuss the basic understanding of various experimental principles involved
4. Demonstrate practical knowledge by applying experimental methods to correlate with the theory.
5. Apply the analytical techniques and graphical analysis to the experimental data

LIST OF EXPERIMENTS

1 Determining Plank's constant and inverse square law
2 Study of Photoconductivity
3 Study of Bio-Savart's Law
4 Determining e/m by Thomson's method
5 Study of Hall Effect.
6 Experiments on single and double slit diffraction and interference with He-Ne Laser
7 Study of I-V characteristics of p-n diode.
8 Determination of thermal conductivity of different solids
9 To measure resistivity of semiconductor by Four Probe method and determination of band gap.
10 Study of Interference using Newton's Ring experiment.
11 To study G.M. tube characteristics and to calculate the dead time.
12 Energy calibration of CsI:Tl radiation detector and energy analysis of an unknown gamma source
13 To determine the numerical aperture of a given fibre optics cable using the far field measurements.
14 Experiments with heat pump
15 Study of Polarization of light using LASER

COURSE OUTCOMES

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

CO1 : Analysis the engineering problems and design the components for the solution
CO2 : Developing skills to utilize the different tools for engineering problems
CO3 : Analyse the results and correlate with theory and its application in industries
CO4 : Design the set-up and utilize for component analysis
CO5 : Identifying the problem and creating the solutions for research and development
CO6 : Analyse the scientific data and learn to be efficient as individual and a team member

TEXT/REFERENCE BOOKS

1. W.R. Runyan , Semiconductor Measurements and Instrumentation, McGraw Hill.
2. Sayer M. & Mansingh A., Measurement, Instrumentation & Experiment Design in Physics and Engineering, Prentice Hall India.
3. Melissinos A.C. and Napolitano J, Experiments in Modern Physics, Academic Press.
4. Nakra B.C. &. Chaudhery K.K , Instrumentation Measurements & Analysis, Tata McGraw Hill.
5. ORTEC Lab Manual, Experiments in Nuclear Science, ORTEC.

24PH102T					Engineering Physics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To master the concepts of vector algebra and the fundamentals of mechanics.
2. To explore the principles of elasticity in solids, band theory of solids and the Physics of semiconductors.
3. Investigate the behavior of waves and oscillations, along with their applications in acoustics and ultrasonics.
4. Gain insights into thermal physics, covering conduction, convection, and radiation, and their practical applications.

UNIT I: MECHANICS **12 Hrs.**

Introduction to vector algebra, Vector fields and scalar fields, Concepts of gradient, Divergence and Curl, Gauss-Divergence Theorem, Stokes' theorem and its applications, The everyday forces of Physics, Work-energy theorem, Rigid body motion and the conservation of angular momentum, Center of mass, Center of gravity, Moment of inertia: Definition, Moment of inertia of simple planar laminas.

UNIT II: PHYSICS OF SOLIDS **10 Hrs.**

Elasticity, Stress & Strain, Hook's law, Young's modulus, Poisson's ratio, Rigidity modulus, Relationship between elastic constants, Properties of solids, electrical conductivity, Wiede-mann Franz Law, Band structure of conductor, insulator and semiconductor, Intrinsic and extrinsic semiconductor, Conductivity of semiconductors, charge concentrations, Hall effect, LED and Solar cells, Magnetism and its origin, Magnetic properties of solids, Physics of superconductors, Applications.

UNIT III: WAVES, OSCILLATIONS AND ACOUSTICS **08 Hrs.**

Waves and oscillations: Types of waves, Simple harmonic motion, Damped simple harmonic motion, types of damping, Forced oscillation, Resonance, Energy Transport in Wave motion. Acoustics & Ultrasonic: Introduction to Sound, Sabine's reverberation theory, Acoustical defects and their remedies, Doppler Effect, Ultrasonic waves, Methods of their generation and detection, Properties and applications of ultrasonic waves.

UNIT IV: THERMAL PHYSICS **12 Hrs.**

Thermodynamic systems (closed and open), Thermodynamic properties and equilibrium, Concepts of heat and work, Laws of thermodynamics, Carnot cycle, Heat transfer-thermal expansion of solids and liquids, Conduction in solids, Thermal conductivity, Forbe's method, Lees' disc method, Thermal insulation and its applications, Thermal Convection and its applications, Newton's law of cooling, Thermal Radiation – emission and absorption radiation, emissive power, Black body radiation, Stefan's laws, Wien's law.

TOTAL: 42 Hrs.

COURSE OUTCOMES

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

CO1 : Describe fundamental concepts of mechanics, such as vector algebra, everyday forces of Physics, Moment of inertia, etc
CO2 : Explain the principles underlying the physics of solids, including elasticity and the behavior of energy bands.
CO3 : Solve problems involving mechanics, solids, waves, oscillations, and acoustics
CO4 : Analyze the behavior of waves, oscillations, and thermal phenomena, including their practical applications
CO5 : Critically evaluate the significance of thermodynamic laws and superconductivity theories in solving real-world problems.
CO6 : Develop solutions and innovative applications in mechanics, solids, waves, and thermal physics by integrating concepts and principles learned throughout the course.

TEXT/REFERENCE BOOKS

1. D. Kleppner and R. J. Kolenkow, An Introduction to Mechanics, Tata McGraw-Hill.
2. D. Halliday, R. Resnick, J. Walker, Fundamentals of Physics, John Wiley & Sons.
3. Sears and Zemansky, University Physics, Pearson publications.
4. M. N. Avadhanulu, P.G. Kshirsagar, A textbook of Engineering Physics, S Chand & Co. Ltd.
5. F. M. A. Wahab, Solid State Physics: Structure and Properties of Materials, Narosa Publishing House Pvt. Ltd
6. Richard, Oscillations and Waves: An Introduction, Taylor & Francis.
7. Y. A. Cengel, Introduction to Thermodynamics and Heat Transfer, Tata McGraw-Hill.
8. B. Lal and N. Subramaniyam, Heat and Thermodynamics, S Chand & Co. Ltd.

24PH102P					Engineering Physics Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To comprehend the operation of diverse electrical, mechanical, and optical instruments utilized within the laboratory setting.
2. To grasp fundamental principles of Physics and apply them effectively in the execution of experiments.
3. To acquire hands-on experience in Physics through experimental work, fostering practical understanding.

LIST OF EXPERIMENTS

1 To determine the acceleration due to gravity 'g' using a simple pendulum.
2 To determine the acceleration due to gravity 'g' using a bar pendulum.
3 To determine the electrical conductivity of metals.
4 To study the characteristics of Si solar cells
5 To explore the usage of Digital Oscilloscope
6 To study the phenomenon of photoconductivity using CdS photo-resistor
7 To determine linear thermal expansion coefficient of solid bodies
8 To study the phenomenon of Hall Effect.
9 To determine volumetric coefficient of expansion of liquids.
10 To study the reflection of ultrasonic waves.
11 To demonstrate/investigate resonance in forced oscillations.
12 To study the principle of heat pump.
13 To determine energy band gap of semiconductor using four probe method.
14 To measure the slit width of single, blade and double slits.
15 To determine e/m using Thomson's method

COURSE OUTCOMES

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

CO1 : Apply mathematical reasoning to analyze the concepts of mechanics
CO2 : Compare and contrast experimental results to determine electrical and thermal conductivity
CO3 : Demonstrate and implement the concepts of waves and oscillations.
CO4 : Investigate the electrical properties of a given semiconductor device
CO5 : Examine the charge transport mechanism in different conductors.
CO6 : Analyze the behavior of waves, oscillations, and thermal phenomena in experiments..

TEXT/REFERENCE BOOKS

1. D. Halliday, R. Resnick, J. Walker, Fundamentals of Physics, John Wiley & Sons
2. C. Kittel, Introduction to Solid State Physics, John Wiley.
3. C.S. Robinson, R, Das, Textbook of Engineering Physics Practical, University Science Press
4. Kittel, Knight and Ruderman, Mechanics - Berkeley Physics Course, Tata McGraw-Hill.
5. Avadhanulu, A text book of engineering Physics, S. Chand & Company, Ltd.
6. Brij Lal, N. Subrahmanyam, Heat and Thermodynamics, S. Chand & Company, Ltd

24ME101P					Workshop Practices					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To understand safety in various manufacturing processes.
2. Learn how to use various measuring tools for engineering applications.
3. Hands on training and preparation of job using wood, metal and sheet as per drawing.
4. Understand various manufacturing processes like machining, welding, soldering and 3D printing for prototypes.

LIST OF EXPERIMENTS

1 Introduction to Workshop safety, layout and identification of various materials- plastic, wood, metals-ferrous and nonferrous, rubber, glass etc.
2 Use of measuring tools for engineering applications
3 Fitting job: Detailed drawing of work piece, use of fitting tools and job preparation.
4 Carpentry job: Detailed drawing of work piece, use of carpentry tools and job preparation.
5 Sheet metal job: Detailed drawing of work piece, use of sheet metal working tools and job preparation.
6 Plumbing job: Internal/External threading, piping network using Tees, Elbows, Reducer, Bends etc
7 Hands on training on mini lathe and milling machine
8 Demonstration of welding, brazing and soldering
9 Soldering and desoldering for PCB
10 3D printing using polymer and metal.

COURSE OUTCOMES

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

CO1 : Define workshop safety and various engineering materials
CO2 : Understand various measuring equipment
CO3 : Apply various workshop tools in preparing job for carpentry, fitting, sheet metal and plumbing
CO4 : Examine various manufacturing operations like welding and machining
CO5 : Evaluate soldering operation for PCB
CO6 : Create prototype using 3D printing

TEXT/REFERENCE BOOKS

1. S. K. Hajra Choudhury, Elements of Workshop Technology, Vol. I & II, Media Promoters and Publishers.
2. H. S. Bawa, Workshop Practice, Tata-McGraw Hill.
3. Kalpakjian S. And Steven S. Schmid, Manufacturing Engineering and Technology, Pearson Education India Edition.
4. Rao P.N., Manufacturing Technology, Vol. I and Vol. II, Tata McGraw Hill House.

24ME102P					Engineering Graphics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
0	0	4	2	4	--	--	--	50	50	100

COURSE OBJECTIVES

1. To cover the fundamental of engineering drawing and standards used in drawing.
2. To explain the students to communicate ideas using orthographic and isometric projection methods.
3. To help students to use CAD software to prepare drawings.
4. To demonstrate the presentation of drawing using sketching and 3D modelling in CAD tool.

LIST OF EXPERIMENTS

1 Introduction to Engineering Graphics: Principles of engineering graphics and their significance, drawing instruments & accessories, lettering and numbering, types of lines, dimensioning methods, basic geometric drawing, reading a drawing.

2 Orthographic Projection: Introduction to projection, types of projection, 1st angle and 3rd angle projection

3 Isometric Projection: Principles of isometric projection – isometric scale, isometric views, conventions, conversion of isometric views to orthographic views and vice-versa

4 Projection of Solids and Development of Surface: Classification of solids, projections of solids like cylinder, cone, pyramid, and prism with its inclination to reference plane, development of surfaces of right regular solids - prism, pyramid, cylinder and cone.

5 Introduction of Computer Aided Engineering Drawing: Demonstrating knowledge of the theory of CAD software, use of software in drawing, CAD software user interface, commands, Coordinate System, menus and toolbars, planes, dimensioning, saving of files, Select and erase objects, zoom tools, and others

6 Basic sketching using CAD tool: Sketch entities using tools – origin, points, lines, circle, arcs, polygons, fillets and chamfer, trim, extend and offset, copy, cut, delete and others

7 Advanced sketching using CAD tool: Sketching entities using relation constrains, Mirror, Patterning, full definition of drawing and others

8 Basic 3D modelling using CAD tool: Extrude, cut, drawing on different planes, editing, symmetric, revolving, and others

9 Computer aided drawing sheets: Preparing drawing sheets, creating different views, section view, drawing templates, and others

COURSE OUTCOMES

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

CO1 : Recalling the fundamentals of engineering graphics by considering basic rules of drawing, dimensioning, and labelling.
CO2 : Explain the principle of projection using orthographic and isometric projection.
CO3 : Represent the 2-dimensional drawing using CAD tool.
CO4 : Construct the 3-dimensional geometries using CAD tool.
CO5 : Apply the concept of engineering drawing by organizing drawing views and applying necessary dimensions by preparing drawing sheets
CO6 : Analyse the intricate details of solid using projection of solid, sectioning of solid and development of lateral surfaces.

TEXT/REFERENCE BOOKS

1. Bhatt N.D., Panchal V.M. & Ingle P.R., Engineering Drawing, Charotar Publishing.
2. Shah P.J., Engineering Graphics, S. Chand Publishing.
3. Agrawal, B. & Agrawal C. M., Engineering Drawing, Tata McGraw Hill Publishers.
4. Hanifan R, Perfecting Engineering and Technical Drawing, Springer International Publishing Switzerland.
5. Corresponding Set of CAD Software Theory and User Manuals.

24CV101T					Environmental Science					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To develop a comprehensive perspective of environment and sustainable development
2. To understand the causes and effects of various types of pollution
3. To develop an understanding of the various strategies for controlling the pollution
4. To introduce the emerging environmental domains

UNIT I : INTRODUCTION TO ENVIRONMENT **05 Hrs.**

Sustainable Development; Sustainable Development Goals; Environmental Studies – Its importance and Multidisciplinary nature, Introduction to Environmental Parameters and their standards (air, water, soil, noise, etc.); Ecosystem and its types, Ideal ecosystem, Biodiversity : Its importance and conservation.

UNIT II : MULTI-SCALE ENVIRONMENTAL POLLUTION (GLOBAL, REGIONAL AND LOCAL) **06 Hrs.**

Pollution, Causes and Effects of different types of pollution : Air Pollution, Water Pollution, Soil Pollution, Solid Waste (organic and Inorganic) Pollution, Hazardous Waste Pollution, Marine Pollution, Noise Pollution, Thermal Pollution, Radioactive Pollution; Introduction to man-made disasters like floods, heat waves, landslides, etc., Introduction to the various instruments for measuring air pollution, water pollution, noise, etc.

UNIT III : ENVIRONMENTAL POLLUTION CONTROL STRATEGIES **09 Hrs.**

Multi-approaches for reducing various types of pollution: Introduction to Water and Wastewater treatment technologies, Air and Noise pollution control techniques, Introduction to different environmental management concepts like Swachh Bharat Mission, Mission LiFE (Lifestyle For Environment), etc. Indian Culture and Traditional Wisdom for managing environment

UNIT IV: EMERGING ENVIRONMENTAL MANAGEMENTS DOMAINS **08 Hrs.**

Concept of Zero Liquid Discharge (ZLD) and the reuse of the treated wastewater, Green Credit Rules - 2023, Clean Development Mechanisms (CDM) and Carbon Credits, Green Buildings, Carbon Footprint and Water Footprint, Green Business, International Environmental Laws, Environmental Auditing

TOTAL: 28 Hrs.

COURSE OUTCOMES:

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

CO-1: Demonstrate comprehension of sustainable development and environmental aspects.
CO-2: Recognize the interdisciplinary characteristics inherent in Environmental studies.
CO-3: Evaluate the impact of various pollutants on the environment.
CO-4: Assess the efficacy of different technologies for environmental pollution control.
CO-5: Analyze different environmental management policies and their implications.
CO-6: Synthesize knowledge about emerging environmental management paradigms.

TEXT-BOOK AND REFERENCE BOOKS:

1. Bharucha Erach, Textbook for Environmental Studies, UGC New Delhi.
2. Daniel B. Botkin & Edwards A. Keller, Environmental Science, Wiley India edition.
3. Miller T. G. Jr., 2006. Environmental Science, Clengage Learning.
4. R. Rajagopalan, Environmental Studies, Oxford University Press.
5. Gilbert Masters and Wendell P. Ela, Introduction to Environmental Engineering and Science, PHI.

24HS102T					Universal Human Values					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
1	0	0	1	1	25	50	25	--	--	100

COURSE OBJECTIVES

1. To understand the need of nurturing human values through the process in value-based education system.
2. To understand and develop a holistic perspective on self-exploration and being in harmony with family, society and nature.
3. To facilitate the students in understanding harmony at all the levels and applying in their profession and work place to lead an ethical life.

UNIT I: HUMAN VALUES AND PROCESS OF VALUE EDUCATION **04 Hrs.**

Human values, human aspirations and the ultimate goal, understanding happiness and prosperity, appraise the meaning of satisfaction and happiness in current scenario, harmony and compatibility, values imbibed education system and process

UNIT II: KNOWING SELF - HARMONY WITH SELF **04 Hrs.**

Understanding self, capabilities and challenges, understanding material (physical facilities) and spiritual needs - need of mind and body, understanding body as an instrument, harmony between mind and body, synchronizing physical health and mental health, practicing healthy habits for healthier me

UNIT III: HARMONY IN RELATIONSHIP – FAMILY, SOCIETY AND NATURE **03 Hrs.**

Harmony in relationships, values for harmony in any human-human interaction, harmony in family, and society, trust and respect for others, self esteem and ego, equality, equity, inclusion and liberation, concept of '*Vasudhaiva Kutumbakam',* understanding co-existence and sync with nature

UNIT IV: HARMONY IN PROFESSION AND ETHICAL BEHAVIOR **03 Hrs.**

Ethical human conduct, acceptance and respect, appraising the qualities of others, professional competence for enabling harmony in system and enabling universal human order, scope of eco-friendly systems, strategies to reach the harmonious ecosystem to reach Universal Human Order '*Sarvabhauma Vyavastha'*

TOTAL : 14 Hrs.

COURSE OUTCOMES

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

CO1 - Understand the significance of human values, its need, and process of value education.

CO2 - Appraise the meaning of happiness and prosperity as short- and long-term goal of life. Understand them and in context of the current scenario

CO3 - Distinguish between the mind and body, physical and spiritual wellbeing for harmony within self

CO4 - Assess the value of harmonious relationship based on trust, respect and enduring its role in all human-human relationships to build harmonious society

CO5 - Understand the importance of harmony with nature and appreciate co-existence for harmonious ecosystem.

CO6 - Create the perfect professional place and work environment following the ethical practices and strategize to uphold the human values at all the levels and interactions.

TEXT/REFERENCE BOOKS

1. R. R. Gaur, R Sangal, G P Bagaria, A foundation course in Human Values and Professional Ethics, Excel books.
2. A. Nagraj, Jeevan Vidya ek Parichay, Divya Path Sansthan, Amarkantak.
3. A. N. Tripathi, Human Values, New Age Intl. Publishers.
4. M. K. Gandhi. The Story of My Experiments with Truth, Fingerprint Publishing.
5. Ivan Illich, Energy & Equity, The Trinity Press, Worcester, and Harper Collins.
6. E. F. Schumacher, Small is Beautiful: a study of economics as if people mattered, Blond & Briggs, Britain.
7. Sussan George, How the Other Half Dies, Penguin Press.

24HS103T					Indian Knowledge System					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE	
1	0	0	1	1	25	50	25	--	--	100

COURSE OBJECTIVES

1. To connect with the tradition of IKS
2. The students will be able to define Philosophical foundations of IKS.
3. To understand Fundamentals of Art and Architecture, Traditional and Historical Town Planning & Ancient Indian Art & Architecture.

UNIT 1 INTRODUCTION TO IKS **07 Hrs.**

- What is IKS? Historical and philosophical foundations
- Knowledge Framework and classifications in IKS
- Indian scheme of knowledge
- The knowledge triangle
- Framework for establishing valid knowledge
- Deductive or inductive logic framework
- Potential fallacies in the reasoning process

UNIT II: IKS AND ENGINEERING DISCIPLINES **07 Hrs.**

- Engineering marvels of ancient India
- Civil engineering: Urban planning, water management
- Materials engineering: Sustainable materials, traditional construction techniques Material science and Metallurgy in IKS
- Mechanical engineering: Robotics and automation in ancient India
- The role of IKS in addressing climate change challenge
- IKS principles for resource management and conservation

UNIT III: IKS AND MATHEMATICS **07 Hrs.**

- IKS and Indian Mathematics, Algebra, Geometry, Trignometry, Binary Mathematics, Magic
- IKS and Indian Astronomy, Pañcāṅga – The Indian calendar system
- Astronomical Instruments -Yantras

UNIT IV: IKS AND OTHER DISCIPLINES **07 Hrs.**

- Indian Administration
- Concept of state,
- Anushashan Parwa of Mahabharat
- Kautilya's Arthshastra
- Social and Political Philosophies of Ancient India
- IKS and Medicine: Ayurveda - A Holistic Approach to Health and Wellbeing

TOTAL: 28 Hrs.

COURSE OUTCOMES

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

CO1 : Define the fundamental concepts of Indian Knowledge System
CO2 : Describe various cost concepts of IKS relevant from engineering perspective.
CO3 : To Apply Mathematics in the Vedas and Śulva SūtraSystems employed for representing numbers Spherical trigonometry &Celestial Sphere
CO4 : To Analyse the science of Astronomy and the different units of time discussed in the texts
CO5 : To be able to weigh the IKS systems vis s vis the current applications in various spheres of understanding
CO6 : To design applications and processes by incorporating thebl traditional knowledge to the present day concerns

TEXT/REFERENCE BOOKS

1. Introduction To Indian Knowledge System: Concepts and Applications by by B. Mahadevan, Nagendra Pavana, Vinayak Rajat Bhat.
2. The Vedas by Sri Chandrasekharendra Saraswati/Sankaracharya of Kanchi Kamakoti Peetham (Author)
3. Indian Knowledge Systems – Vol 1 & 2 by Avadhesh K. Singh, Kapil Kapoor

UG Curriculum (2024 onwards)

Semester 3

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 3	Pro		Civic and Social Service Internship	0	0	2	2	1
	BSC		Maths-III	3	1	0	4	4
	ESC		Introduction to Artificial Intelligence	3	0	0	3	3
	PC		Chemical Process Calculations	3	1	0	4	4
	PC		Mechanical Unit Operations	3	0	0	3	3
	PC Lab		Mechanical Unit Operations Lab	0	0	2	2	1
	PC		Fluid Mechanics	3	0	0	3	3
	PC Lab		Fluid Mechanics Lab	0	0	2	2	1
				15	**2**	**6**	**23**	**21**

					Introduction to Artificial Intelligence for Chemical Engineers					
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. The course is designed to provide the link between artificial intelligence and real time processes in various practical applications.
2. It provides the basic concepts of machine learning with examples for linkage with automation based industrial procedures.
3. The level of the course is chosen to be such that all students aspiring to be a part of artificial intelligence directly or indirectly in near future should get these concepts.
4. The course attempt to apply the concept of artificial intelligence for the design, stability analysis and controllability of chemical processes.

UNIT I: FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE **8 Hrs.**

Introduction to AI: Definitions, history, importance, ethics, challenges, and future Directions. Evolution of AI technologies and their impact across various sectors, Relevance to chemical engineering. Agents of Artificial Intelligence: Introduction to AI agents, environments, and the types of agents (simple reflex agents to learning agents), focusing on their potential applications in process control and optimization. Understanding the working principle of fuzzy and ANN

UNIT II: ADVANCED AI TECHNOLOGIES AND METHODS **12 Hrs.**

Evolutionary Computing (EC): Principles of evolutionary computing, with a focus on genetic algorithms, covering their structure and application in optimization problems found in chemical engineering. Natural Language Processing (NLP): Introduction to NLP and its applications in analyzing scientific literature, patents, and documentation within the chemical engineering domain.

UNIT III: OPTIMIZATION TECHNIQUES IN AI **12 Hrs.**

Genetic Algorithms (GA): Detailed exploration of GAs for solving complex optimization problems in chemical engineering. Simulated Annealing (SA) and Particle Swarm Optimization (PSO): Introduction and application of SA and PSO in finding optimal solutions under constraints typical in chemical processes.

UNIT IV: APPLICATION OF AI IN CHEMICAL ENGINEERING **10 Hrs.**

AI in Process Control: Utilizing AI for improving process control strategies, including predictive maintenance and real-time optimization. AI in Material Science: Leveraging AI for material discovery and development, emphasizing the use of AI in predicting material properties and formulations. AI in Environmental Engineering: Application of AI in waste treatment, emission control, and environmental monitoring.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

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

CO1 : Understand basics, history, and evolution of AI, differentiating it from traditional computing.
CO2 : Identify and explain AI agents and their roles in chemical engineering.
CO3 : Apply fuzzy systems and neural networks in chemical engineering problem-solving.
CO4 : Design and implement genetic algorithms and deep learning for chemical engineering optimization.
CO5 : Utilize AI optimization techniques to enhance chemical engineering processes.
CO6 : Critically assess AI's impact and ethical considerations in chemical engineering.

TEXT/REFERENCE BOOKS

1. Patrick Henry Winston, Artificial Intelligence, 3rd Edition, Addison-Wesley Publishing Company, 2004.
2. Nils J. Nilsson, Principles of Artificial Intelligence, Illustrated Reprint Edition, Springer Heidelberg, 2014.
3. Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach, 3rd Edition, PHI, 2009.
4. Nils J. Nilsson, Quest for Artificial Intelligence, 1st Edition, Cambridge University Press, 2010.

					Chemical Process Calculations					
Teaching Scheme					Examination Scheme					
					Theory			Practical		TotalMarks
L	T	P	C	h/Week	MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

1. Learn to use the correct unit conversions and dimensions and use them in process calculations
2. Synchronize the understanding of stoichiometry and different unit operations & processes
3. Handle the material balances for a system with and without reactions and/or with recycle / bypass operations.
4. Accustom students to different forms of energy, terminologies of heat and energy and perform energy balances

UNIT 1 BASIC CONCEPTS OF CHEMICAL PROCESSES **14 h**

Units and dimensions, basic chemical calculations, dimensional consistency, unit processes and unit operations, Concepts of atomic weight, equivalent weight and mole. Composition of solids, liquids and solutions (weight percent, mole percent, molarity, normality etc.), other expressions for concentration, Average molecular weight and density, Gaseous mixtures, Ideal gas laws and its applications, Raoult's law, Henry's law, Amagat's Law & Dalton's law, Humidity and Saturation

UNIT 2 MATERIAL BALANCES **15 h**

Material balance for non-reacting multi-phase systems, solving material balance problems without chemical reactions of unit operations like Absorption and Stripping, Distillation, Extractions and Leaching, Drying, Evaporation, crystallization, Mixing/Blending, etc. material balance for systems with recycle and bypass, material balances on systems with reactions, Concept of limiting and excess reactants, percentage conversion, selectivity and yield, properties of gases, liquids and solids, ideal and non-ideal gas calculations, equations of state, phase equilibria for ideal and real mixtures, humidity and saturation

UNIT 3 ENERGY BALANCES **15 h**

Terminologies, specific heat capacity, enthalpy, heat of formation, combustion, reaction, solutions, energy balances without reactions, for chemical reactions, isothermal systems, adiabatic systems, simultaneous material and energy balances, unsteady state material and energy balances.

UNIT 4 FUEL AND COMBUSTION **12 h**

Types of fuels, proximate and ultimate analysis of fuel, combustion theory, heating value of fuels. Calculations involving theoretical and excess air, heat and material balances of combustion processes, analysis of products of combustion calorific value – HCV & LCV.

Maximum 56 h

COURSE OUTCOMES

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

CO1 : Recall the correct unit conversions and dimensions for different variables for chemical calculations.
CO2 : Relate the stoichiometry in material and energy balances for different unit operations and processes.
CO3 : Solve the material balances of process system with and w/o reactions including recycle / bypass operations.
CO4 : Describe energy changes in liquid and gases accompanying various chemical reactions with terms used to associate energy changes in different phases.
CO5 : Evaluate fuel quality and device requirements of gases in combustion.
CO6 : Elaborate and build the mass and energy requirements of the process.

TEXT/REFERENCE BOOKS

1. D. M. Himmelblau, J.B Riggs, Basic Principles and Calculations in Chemical Engineering, 8th Edition, PHI, 2012
2. O. A. Hougen, K.M. Watson and R. A. Ragatz, Chemical Process Principles – Part 1, 2nd Edition, John Wiley
3. Narayanan K.V., & Lakshmikutti B., Stoichiometry & Process Calculations, 1st edition, Prentice Hall, 2006.
4. B.I. Bhatt & S.B. Thakore, Stoichiometry, Tata McGraw Hill Book Company, 5th Edition, 2010

					Mechanical Unit Operations					
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. Able to understand importance and applications mechanical unit operations in process industries.
2. Able to learn the techniques of solid characterization, size reduction and handling operations.
3. Able to understand solid-fluid operations including filtration, mixing, agitation transportation.
4. Able to compare the solid transportation methods and equipment for appropriate application.

UNIT 1 SOLID CHARACTERIZATION – CLASSIFICATION AND SIZE REDUCTION **12 h**

Introduction: Unit operations and their role in chemical industries. Properties and handling of particulate solids: Characterization of solid particles, Properties of masses of particles, Classification of solids, sieving and screening equipment's, Mixing of solids. Size reduction: Laws of size reduction, energy relationships in size reduction, power requirement, work index. Methods of size reduction, classification of equipment - crushers, grinders, disintegrators for coarse, intermediate and fine grinders, Ultrafine grinders.

UNIT 2 SOLID-FLUID OPERATIONS **10 h**

Gravity settling: Free and Hindered settlings, sedimentation, thickening, elutriation, double cone classifier, rake classifier, bowl classifier. Centrifugal separation-continuous centrifuges, design of basket centrifuges; Flow through packed bed: Fixed bed and Fluidized bed, Pneumatic conveying; industrial dust removing equipment, cyclones and hydro cyclones, electrostatic and magnetic separators, heavy media separations, floatation.

UNIT 3 SOLID FLUID SEPARATION – FILTRATION **10 h**

Theory of filtration, Batch and continuous filters, Flow through filter cake and filter media, compressible and incompressible filter cakes, filtration equipment's -selection, operation and design of filters and optimum cycle of operation, filter aids.

UNIT 4 STORAGE AND TRANSPORTATION OF SOLIDS **10 h**

Agitation and mixing of liquids. Storage and conveying of solids - Bunkers, silos, bins and hoppers. Transportation of solids in bulk: different types of conveyers and their performance characteristics.

Maximum 42 hours

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 : Choose the techniques of mechanical operations to meet the need of chemical Industries.
CO2 : Ability to select suitable size reduction equipment and solid-solid separation method.
CO3 : Understanding fluid flow through packed and fluidized beds.
CO4 : Identify different types of mixing, agitation and conveying of solids and estimating the power requirement.
CO5 : Determination of the static and dynamic principles of separation for ores in chemical industries.
CO6 : Design of filtration equipment by considering constant and variable pressure governing equations.

TEXT/REFERENCE BOOKS

1. J. M. Coulson and J. F. Richardson, Particle Technology and Separation Processes, 5th edition, Elsevier, 2006
2. W. L. McCabe and J. C. Smith, Unit Operations of Chemical Engineering, 7th edition, McGraw Hill Education, 2014.
3. W. L. Badger and J. T. Banchero, Introduction to chemical engineering, 1st edition, McGraw-Hill Education, 2001
4. L. A. Wenzel, C. W. Clump, L. Maus, L. B. Andersen, A. S. Foust, Principles of unit operations, 2nd edition, Wiley, 2008
5. A. Swain, Mechanical Operations, 1st edition, McGraw Hill Education, 2017

					Mechanical Unit Operations Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Analyse the complex engineering problem behind working of a mechanical operation equipment.
2. To investigate the data based upon experiments performed and apply the knowledge of data interpretation, design of experiments and statistical analysis and arrive at a solution by comparing with industrial equipment.
3. Able to understand the proper engineering practices in a chemical process industry with emphasis upon health, safety, society, environment, and sustainable development.

SR.	LIST OF EXPERIMENTS
1	Screen analysis and determining of different mean diameters using a sieve shaker
2	Size reduction and characteristics of jaw crusher
3	Size reduction and characteristics of roll crusher
4	Size reduction and characteristics of ball mill
5	Size reduction and characteristics of Hammer mill
6	Determination of effectiveness of a screen
7	Study of fluidization process and calculation of minimum fluidization velocity
8	To determine the Collection efficiency of the cyclone separator
9	To determine the Average specific cake resistance, Filter medium resistance and Cake weight for the horizontal filter press
10	To perform the operational characteristics of Top Driven Centrifuge
11	To plot the mixing index vs. mixing time curve for Ribbon Blender
12	To study the working of Screw Conveyor

COURSE OUTCOMES

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

CO1 : Relate the classical knowledge of basic sciences and mathematical correlations to solve equations based on mechanical unit operations in Laboratory as a part of team

CO2 : Demonstrate the design and working of mechanical unit operations and appreciate the importance of health, hygiene, safety and sustainable development

CO3 : Apply data interpretation techniques, plotting graphs based on experiments performed and using design of experiments for data optimization

CO4 : Take part in successful completion of an experiment as a part of team building exercise and follow ethical practices judiciously.

CO5 : To learn importance of effective communication means both written and oral to write good laboratory observation and reports

CO6 : Elaborate the importance of difference mechanical unit operations as a lifelong learning exercise in order to comprehend the technological change

TEXT/REFERENCE BOOKS

1. Mechanical Operations Lab Manual
2. A. Swain, Mechanical Operations, McGraw Hill Education, 1st edition, 2017
3. W. L. McCabe and J. C. Smith, Unit Operations of Chemical Engineering, 7th edition, McGraw Hill Education, 2014.
4. W. L. Badger and J. T. Banchero, Introduction to chemical engineering, 1st edition, McGraw-Hill Education, 2001
5. L. A. Wenzel, C. W. Clump, L. Maus, L. B. Andersen, A. S. Foust, Principles of unit operations, 2nd edition, Wiley, 2008

					Fluid Mechanics					
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. Develop basic concepts of fluid flow and learn flow analysis leading to problem-solving skills.
2. Understand the concept of a flow system involving various flow types.
3. Design and analysis of fluid transportation devices and systems including agitation and mixing.
4. Understand the principles of the flow measuring systems for various flow situations.

UNIT I FLUID STATIC AND ITS APPLICATION **10 h**

Introduction to fluid mechanics: definition and properties of fluid, Fluid statics-Pressure distribution in a fluid, Dimensional Analysis: Different methods of dimensional analysis applied to fluid flow problems, Types of flow, relationship between shear stress and pressure gradient, fluid flow in different channels, Hagen-Poiseuille equation, losses in pipes and fittings.

UNIT II BASIC EQUATIONS OF FLUID FLOW **12 h**

Navier-Stokes Equations, Continuity equation, Bernoulli equation, Euler equation. Equation of motion. Darcy-Weisbach equation for frictional head loss, friction factor, Moody diagram. Velocity profile and boundary layer calculations for turbulent flow.

UNIT III TRANSPORTATION OF FLUIDS **10 h**

Handling of fluids: Pumps, compressors and blowers for handling different fluids, Standards for pumps, compressors and blowers, valves, pipe fittings and their standards, power requirement for flow. Piping layout and economical pipe diameter.

UNIT IV METERING OF FLUIDS **10 h**

Flow metering devices: orifice meter, venturi meter, rotameter, pitot tube, anemometer etc. Flow through open channels such as notches, weirs, nozzles. Vacuum producing devices; two phase flow: basic principles and applications.

Maximum 42 hours

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 : Define principles of fluid mechanics operations
CO2 : Explain the theoretical importance and relevance of fluid flow in chemical process industry
CO3 : Identify and apply the theoretical concept of fluid flow in chemical process industry
CO4 : Comprehend and analyse fluid mechanics problems with the application of conservation principles of mass, energy and the momentum
CO5 : Evaluate fluid mechanics problems with the application of conservation principles of mass, energy, momentum.
CO6 : Design fluid transportation systems such as pumps, compressors, and pipe network etc, and choose the fluid transportation devices for process applications

TEXT/REFERENCE BOOKS

1. W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering 7th edition, McGraw Hill 2014.
2. S. Foust, L.A. Wenzel, C.W. Clump, L.B. Andersen. Principles of Unit Operations, 2nd edition, Wiley, 2008.
3. P N Modi and S M Seth, Hydraulics and Fluid Mechanics, 19th edition, Standard Book House, 2009.
4. Frank M. White, Fluid Mechanics, 6th edition, Tata McGraw-Hill, 2008.
5. Pritchard, Philip J., and John W. Mitchell. Fox and McDonald's Introduction to Fluid Mechanics. John Wiley & Sons, 2016.

					Fluid Mechanics Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Learn to perform experiments and analyse and interpret the observations yielded.
2. To compare the results of analytical models introduced in lecture to the actual behaviour of real fluid flows.
3. To discuss and practice standard measurement techniques of fluid mechanics and their applications.
4. Learn to design experimental models, combining the observations and theoretical understandings.

SR.	LIST OF EXPERIMENTS
1	Study of flow regimes by Reynolds's apparatus
2	Study of Bernoulli's equation
3	Determination of Viscosity by efflux time measurement
4	Study of friction factor in close conduits
5	Study of minor losses and determination of equivalent length of pipe fittings
6	Study of venturimeter
7	Study of orifice meter
8	Calibration of rotameter
9	Studies of Pitot tube
10	Characteristics of centrifugal pump
11	Study of friction factor in annular flow
12	Determination of Viscosity by Stokes's Law

COURSE OUTCOMES

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

CO1 : To relate the theoretical and practical concepts of fluid mechanics used in industry.

CO2 : Compare the results of analytical study introduced in lecture to the actual behaviour of real fluid flows and draw correct and sustainable conclusions.

CO3 : Develop the ability to work in groups on small design projects that are appropriate to the course.

CO4 : Categorize ethical issues associated with decision making and professional conduct.

CO5 : Assess the ability to write clear lab reports.

CO6 : Take part in successful completion of an experiment as a part of team building exercise and follow ethical practices judiciously.

TEXT/REFERENCE BOOKS

1. Fluid Mechanics Lab Manual
2. W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering 7th edition McGraw Hill 2014.
3. Frank M. White, Fluid Mechanics, 6th edition, Tata McGraw-Hill, 2008.
4. Pritchard, Philip J., and John W. Mitchell. Fox and McDonald's Introduction to Fluid Mechanics. John Wiley & Sons, 2016.

UG Curriculum (2024 onwards)

Semester 4

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 4	Pro		Industrial Orientation	0	0	0	0	0
	OE		Open Elective 1 (Inter-School)	3	0	0	3	3
	ESC		Chemical Engineering Industry 4.0	2	0	0	2	2
	ESC Lab		Chemical Engineering Industry 4.0 Lab	0	0	2	2	1
	PC		Introduction to Numerical Methods for Chemical Engineers	3	1	0	4	4
	PC		Chemical Engineering Thermodynamics	3	0	0	3	3
	PC Lab		Chemical Engineering Thermodynamics Lab	0	0	2	2	1
	PC		Heat Transfer	3	0	0	3	3
	PC Lab		Heat Transfer Lab	0	0	2	2	1
	PC		Chemical Process Technology	3	0	0	3	3
	PC Lab		Chemical Process Technology Lab	0	0	2	2	1
				17	**1**	**8**	**26**	**22**

					Chemical Engineering Industry 4.0					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

1. To learn overview of Industry 4.0
2. Acquire and fine-tune the skills and chemical engineering applications of data and machine learning.
3. Gain an understanding of IoT, and automation in chemical engineering.
4. Understand recent developments of biomedical engineering.

UNIT I INTRODUCTION AND BASIC CONCEPTS OF INDUSTRY 4.0 **6 h**

Introduction to Industry 4.0, Definition, General framework, Application areas, Introduction to the Evolution of Industrial revolutions, Key features, Need and benefits, Introduction to Industry 4.0 core technologies: Big data, Advanced Robotics, Simulation, Integration, Internet of Things (IoT), Artificial Intelligence (AI), Cybersecurity, Cloud computing, Additive manufacturing and Augmented Reality. Overview of machine learning for Industry 4.0. Transformation of industrial processes through the integration of modern technologies such as sensing and actuation, communication, and computational processing.

UNIT II ROLE OF DATA AND MACHINE LEARNING FOR CHEMICAL ENGINEERS **8 h**

Fundamentals of python with emphasis on Numpy, Pandas, Mathplotlib, OpenCV, Tensorflow, Keras, Data handling, Data Visualization, Logistic regression, fundamentals of Artificial Neural Network (ANN), Convolutional Neural Network (CNN), use of data and machine learning in chemical and biochemical process industries, machine learning for chemical reactor design, machine learning for controlling chemical unit operations, machine learning for plant logistics.

UNIT III IOT, ROBOTICS, AND AUTOMATION FOR CHEMICAL/BIOCHEMICAL ENGINEERS **7 h**

Fundamentals of Arduino, ultrasonic sensors, temperature sensors, IR sensors and their applications in chemical process industries and biochemical industries. Design of IoT enabled smart Air Quality Index (AQI) monitoring device, Portable Design of Weather Monitoring unit deployable in process plant, interfacing real time data on cloud for smart plant monitoring, IoT enabled automated plant safety monitoring device, advanced process control in chemical industry, chemical plant simulator, development of mobile app/web app for smart plant monitoring using open source resources.

UNIT IV BIOTECHNOLOGY AND BIOMEDICAL ENGINEERING **7 h**

Targeted Drug delivery, Robotic Surgery, 3D bio printing, Biomedical image analysis: MRI, Ultrasound image, biosensors, types of biosensors, Point of Care Testing device, development of portable opto-electronic devices, role of self-propelled Micro/-nano motors in healthcare sector, AI in healthcare with emphasis on POCT devices, patient health monitoring, and telemedicine.

Maximum 28 h

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 : Understand the fundamental concepts of Industry 4.0.
CO2 : Understand the basics of AI, augmented reality, IoT, and Cyber security.
CO3 : Understand the fundamentals of python and useful libraries.
CO4 : Understand the use of data science, ML in chemical engineering.
CO5 : Understand the role of automation, and IoT in chemical and biochemical engineering.
CO6 : Understand the concepts of advanced biomedical engineering.

TEXT/REFERENCE BOOKS

1. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning, 3rd edition, Packt Publishing, 2019
2. Eric M. H. Goh, Learn by Examples - A Quick Guide to IoT with Arduino and Data, Kindle Edition, SV Book, 2018
3. Arvind N. Shukla, Rehana Quereshi, Advanced Biomedical Engineering, 1st edition, Discovery Publishing House, 2016
4. Online resources from Github and similar repositories.

					Chemical Engineering Industry 4.0 Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. To learn practical aspects of Industry 4.0
2. Acquire engineering grasp over python coding.
3. Gain idea of open-source fluid flow simulations.
4. Understand applications of machine learning for core engineers.

SR.	LIST OF EXPERIMENTS
1	Data analysis and data visualization using the Python programming language
2	Implementation of logistic regression problem in python.
3	Implementation of Artificial Neural Network (ANN) using python.
4	Development of plant dashboard using python.
5	Implementation of Convolutional Neural Network (CNN) for biomedical image analysis.
6	Solving fluid flow equation with python programming.
7	Introduction to Open Source CFD simulation software.
8	Introduction to ASPEN.
9	Arduino for portable spectrophotometric detection.
10	Arduino for water level monitoring using ultrasonic sound.

COURSE OUTCOMES

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

CO1 : Understand the concept of Industry 4.0 and its significance
CO2 : Understand the resource requirements for the implementation of Industry 4.0
CO3 : Learn the Simulation Packages for Industry 4.0
CO4 : Explore the concept of fluid flow simulations
CO5 : Inspect embedded platform applications for Industry 4.0
CO6 : Synthesise the solution for the given Industry 4.0 related problem

TEXT/REFERENCE BOOKS

1. Ustundag Alp, and Emre Cevikcan, Industry 4.0: Managing the Digital Transformation, Springer, 1st Edition, 2018
2. Kaushik Kumar, Divya Zindani, and J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0., 1st edition, CRC Press/Taylor & Francis, 2019.
3. S. V. Patthankar, Numerical Heat Transfer and Fluid Flow -Patankar, CRC Publication, 1st Edition, 2017.
4. Sebastian Raschka and Vahid Mirjalili, Python Machine Learning, 3rd edition, Packt Publishing, 2019
5. Eric M. H. Goh, Learn by Examples - A Quick Guide to IoT with Arduino and Data, Kindle Edition, SV Book, 2018

					Introduction to Numerical Methods for Chemical Engineers					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

Pre-requisite:

Chemical Process Calculations, Mathematics-I, II

Course Objectives:

1. To introduce the numerical solutions of analytical problems.
2. To understand the programmable methods to solve engineering problems.
3. To implement the logical sequencing of numerical methods

UNIT I NUMERICAL SOLUTIONS TO ALGEBRAIC EQUATIONS **14 h**

Mathematical Modelling and Chemical Engineering Problem Solving, Conservation Laws, Taylor Series and error propagation, Bracketing Methods – Graphical methods, bisection method and false position method, Open methods – Fixed Point iteration, Newton Raphson, Secant method, Linear Algebraic Equations Gauss Elimination, LU Decomposition Gauss Siedel

UNIT II NUMERICAL APPROXIMATIONS AND DATA MANOEUVRING **14 h**

Curve Fitting – Linear Regression, Multiple Linear Regression, Polynomial Regression, Non-linear regression, Interpolation, Spline interpolation, Fourier series, numerical integration and differentiation – trapezoidal rule, Simpson's rules.

UNIT III NUMERICAL SOLUTIONS TO ORDINARY DIFFERENTIAL EQUATIONS **14 h**

Ordinary differential equations – Euler Method, Runge Kutta – 1,2,3,4 Methods, Adaptive RK Methods, Stiffness, Boundary value and Eigen Value problems, chemical engineering problems: case studies

UNIT IV NUMERICAL SOLUTIONS TO PARTIAL DIFFERENTIAL EQUATIONS **14 h**

Partial differential equations – Finite difference: elliptic equations, parabolic equations, Finite element method – general approach, finite element in one dimension, two dimensional problems, chemical engineering problems: case studies

Maximum 56 h

COURSE OUTCOMES:

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

CO1 : To recognize the need and efficacy parameters of numerical methods

CO2 : To model chemical engineering problems as solvable by numerical methods

CO3 : To implement the numerical solutions in chemical engineering problem solving

CO4 : To numerically solve algebraic equations and data manoeuvring problems

CO5 : To solve ODE and PDE equations in Chemical Engineering through numerical methods

CO6 : To design an independent solution strategy using various numerical methods

Texts and References

1. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, 8th edition, McGraw-Hill Education, 2021.
2. Victor J. Law, Numerical Methods for Chemical Engineers Using Excel, VBA, and MATLAB, 1st edition, CRC Press, 2013.
3. Abdelwahab Kharab and Ronald B. Guenther, An Introduction to Numerical Methods: A MATLABORATORY Approach, 5th edition, Chapman and Hall/CRC, 2023.
4. Amos Gilat, Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, 1st edition, John Wiley & Sons, 2007.
5. Michael R. King and Nipa A. Mody, Numerical and Statistical Methods for Bioengineering: Applications in MATLAB, 1st edition, Cambridge University Press, 2010.

					Chemical Engineering Thermodynamics					
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 a fundamental understanding of various laws of thermodynamics.
2. To develop an understanding of the PVT behaviour of a pure component.
3. To derive various thermodynamic properties in terms of measurable variables.
4. To provide a framework for the phase behaviour of pure components and mixtures.

UNIT I: LAWS OF THERMODYNAMICS **10 h**

Scope of thermodynamics, system & surroundings, quasi-static processes, diathermal and adiabatic boundaries, 0^{th} law and its implications, thermodynamic work, first law and its implications, heat, heat capacities, state of a pure component, closed thermodynamic system, statements of the second law, the entropy of system and surroundings, spontaneity, first and second laws for open systems.

UNIT II: VOLUMETRIC PROPERTIES OF PURE FLUIDS **10 h**

General nature of PVT behaviour 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 factor calculations using generalized correlation table, Virial equation of state.

UNIT III: THERMODYNAMIC PROPERTY RELATIONS AND INTRODUCTION TO VLE **10 h**

Fundamental property relations, Maxwell's relations, Enthalpy and Entropy as Functions of T and P, Internal Energy and Entropy as Functions of T and V, The Gibbs Energy as a Generating Function, Residual properties from various equations of state, generalized property correlations for gases, Two-phase system, Clapeyron equation, Antoine equation, Raoult's law, Modified Raoult's law, Bubble point and Dew point calculations.

UNIT IV: SOLUTION THERMODYNAMICS **12 h**

Gibbs phase rule, chemical potential, and condition for phase equilibrium, partial properties, the ideal-gas-state mixture model, fugacity and fugacity coefficient calculations for pure species and mixtures, the ideal-solution model, Excess properties, property changes of mixing, heat effects of mixing processes.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Outline the laws of thermodynamics.
CO2 : Understand the PVT behaviour of pure fluids.
CO3 : Apply different equations of state to find out the molar volumes of gases, saturated vapours, and liquids.
CO4 : Analyse the thermodynamic properties relations in pure species and mixtures.
CO5 : Evaluate the residual properties from generalized correlations and equations of state.
CO6 : Solve the vapor-liquid equilibrium problems such as bubble and dew point and azeotropic concentration.

TEXT/REFERENCE BOOKS

1. J.M. Smith, H.C. Ness, M. Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill, Special Indian Edition.
2. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press, 1997.
3. J.B. Ott, J. Boerio-Goates, Chemical Thermodynamics: Principles and Applications, Academic Press, 2000.
4. J. M. Prausnitz, R. N. Lichtenthaler, E. G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3^{rd} edition, Prentice Hall PTR.
5. B. E. Poling, J. M. Prausnitz, J. P. O'Connell - The properties of gases and liquids, 5^{th} edition, McGraw-Hill Professional.

					Chemical Engineering Thermodynamics 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 provide students with hands-on training on the free and open-source tools related to the most common thermodynamic calculations in the chemical industries.
2. To expose the students to a numerical programming tool to solve complex thermodynamic calculations.

LIST OF EXPERIMENTS

1 Understanding and creating cubic equations of state models in Julia programming language.
2 Estimation of pure component enthalpy, entropy, residual enthalpy, and residual entropy using cubic equations of state models.
3 Computation of Gibbs free energy, Helmholtz free energy, chemical potential, fugacity coefficients.
4 Computation of isothermal compressibility, isobaric expansivity, and isobaric and isochoric heat capacities.
5 Computation of mixing functions for a specified property.
6 Application of iterative methods to find solution of cubic equations of state.
7 Dew point temperature and pressure estimation using the equation of state and activity coefficient model.
8 Bubble point temperature and pressure estimation using the equation of state and activity coefficient model.
9 Generating T-xy, P-xy, y-x diagram for vapor-liquid and prediction of presence of azeotropes.
10 Generating and understanding of residue curve map for multicomponent system.
11 Development of flash-drum for isothermal and adiabatic processes.

COURSE OUTCOMES

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

CO1 : Identifying the cubic equation of state models.
CO2 : Understanding the iterative methods to solve cubic equations of state.
CO3 : Determine the pure component properties and residual properties.
CO4 : Calculating the mixing functions to evaluate the mixture properties.
CO5 : Evaluating the bubble point and dew point properties using equations of state models.
CO6 : Develop the VLE data and various related diagrams.

TEXT/REFERENCE BOOKS

1. J. M. Prausnitz, R. N. Lichtenthaler, E. G. Azevedo, Molecular Thermodynamics of Fluid-Phase Equilibria, 3rd edition, Prentice Hall PTR.
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. Smith, H.C. Ness, M. Abbott, Introduction to Chemical Engineering Thermodynamics, McGraw-Hill, Special Indian Edition.
4. Y.V.C. Rao, Chemical Engineering Thermodynamics, University Press, 1997.
5. J.B. Ott, J. Boerio-Goates, Chemical Thermodynamics: Principles and Applications, Academic Press, 2000.

					Heat Transfer					
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 modes of heat transfer and their application in process industries.
2. To understand heat balance equations in heat exchangers.
3. To understand heat transfer with phase change
4. To understand heat transfer holistically combining different modes of heat transfer.

UNIT I CONDUCTION BASED HEAT TRANSFER **10 Hrs.**

Introduction and fundamentals of heat transfer, heat transfer rate, flux, resistances, thermal conductivity of materials, Conduction through objects in series, Insulation, Unsteady state heat conduction, lumped heat capacity system, transient heat flow in a semi-infinite solid.

UNIT II CONVECTION BASED HEAT TRANSFER **12 Hrs.**

Film and overall heat transfer coefficients, Solid-fluid heat transfer, Natural and forced convection, Laminar and turbulent flow heat transfer, Nucleation and boiling, Film wise and drop wise condensation, Condenser design, Fundamentals of pervaporation.

UNIT III RADIATION BASED HEAT TRANSFER **8 Hrs.**

Black and gray body radiations, Plank's law, Stephen-Boltzmann law, View factor, Luminous and non-luminous gases.

UNIT IV HEAT TRANSFER EQUIPMENT **12 Hrs.**

Combined heat transfer, Heat Exchangers, Coefficients for scale deposits, L.M.T.D. in heat exchangers, Effectiveness, N T U method in finned tube heat exchangers, TEMA specifications-based analyses.

TOTAL HOURS: 42 Hrs.

COURSE OUTCOMES

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

- **CO1** : Define the basic principles of heat transfer operations, related to different mode of heat transfer.
- **CO2** : Analyse heat transfer operations involving combinations of heat transfer principles.
- **CO3** : Apply principles of heat transfer operations involving conduction, convection, radiation including phase change.
- **CO4** : Analyse the problems related to heat transfer equipment.
- **CO5** : Understand industrial practices regarding heat transfer.
- **CO6** : Design heat transfer equipment based upon the conditions given in the problem statement.

TEXT/REFERENCE BOOKS

1. J. M. Coulson and J. F. Richardson, Chemical Engineering Vol. I and II, 6th edition, Elsevier Press, 2000.
2. W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering, 7th edition, McGraw Hill 2014.
3. J. P. Holman and S. Bhattacharyya, "Heat Transfer", McGraw Hill Education, 10th edition, 2011
4. B. K. Dutta, Heat Transfer: Principles and Applications, 1st edition, PHI Publishers, 2014
5. A. M. Flynn, T. Akashige, & L. Theodore, Kern's Process Heat Transfer, 2nd edition, Wiley-Scrivener, 2019
6. J. P. Holman & S. Bhattacharyya, Heat Transfer, 10th edition, McGraw Hill Education, 2011
7. Yunus A. Çengel, Heat Transfer: A Practical Approach, 2nd edition, McGraw-Hill, 2004
8. T. L. Bergman, A. S. Lavine, F. P. Incropera, & D. P. DeWitt, Incropera's Principles of Heat and Mass Transfer, 7th edition, Wiley, 2011

					Heat Transfer Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. To understand the modes of heat transfer (conduction, convection and radiation) and their application in process industries.
2. To understand heat balance equations in heat exchangers.
3. To understand heat transfer with phase change
4. To understand combined heat transfer, this involves all modes of heat transfer.

SR.	LIST OF EXPERIMENTS
1	Heat transfer in Natural convection
2	Heat Transfer in Forced Convection
3	Stefan Boltzmann constant verification
4	Parallel and counter flow heat exchangers
5	Emissivity apparatus
6	Thermal conductivity of Insulating powder
7	Thermal conductivity of the metal bar
8	Heat transfer by vertical and horizontal heat exchanger in natural convection
9	Plate type heat exchanger
10	Finned tube heat exchanger
11	Heat transfer in agitated vessel
12	Evaporator

COURSE OUTCOMES

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

CO1 : Define the basic principles of heat transfer operations, related to different mode of heat transfer.
CO2 : Analyse heat transfer operations involving combinations of heat transfer principles.
CO3 : Apply principles of heat transfer operations involving conduction, convection, radiation including phase change.
CO4 : Analyse the problems related to heat transfer equipment.
CO5 : Understand industrial practices regarding heat transfer.
CO6 : Design heat transfer equipment based upon the conditions given in the problem statement.

TEXT/REFERENCE BOOKS

1. Heat Transfer Laboratory Manual
2. J. M. Coulson and J. F. Richardson, Chemical Engineering Vol. I and II, 6th edition, Elsevier Press, 2000.
3. W. L. McCabe and J. C. Smith, P. Harriot, Unit Operations of Chemical Engineering, 7th edition, McGraw Hill 2014.
4. J. P. Holman and S. Bhattacharyya, "Heat Transfer", McGraw Hill Education, 10th edition, 2011
5. B. K. Dutta, Heat Transfer: Principles and Applications, 1st edition, PHI Publishers, 2014
6. A. M. Flynn, T. Akashige, & L. Theodore, Kern's Process Heat Transfer, 2nd edition, Wiley-Scrivener, 2019
7. J. P. Holman & S. Bhattacharyya, Heat Transfer, 10th edition, McGraw Hill Education, 2011
8. Yunus A. Çengel, Heat Transfer: A Practical Approach, 2nd edition, McGraw-Hill, 2004
9. T. L. Bergman, A. S. Lavine, F. P. Incropera, & D. P. DeWitt, Incropera's Principles of Heat and Mass Transfer, 7th edition, Wiley, 2011

					Chemical Process 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. Provide a comprehensive overview of various organic and inorganic chemical manufacturing industries.
2. Introduce the understanding of the processes, flow diagram, process parameters, and equipment utilized in chemical industries
3. Properties, usage, and application of intermediate chemicals and products.
4. Bring an understanding of engineering problems in process manufacturing and solve them by applying chemical engineering knowledge

UNIT I INTRODUCTION AND RAW MATERIALS **7 h**

History of Organic and Inorganic Chemicals and their importance, Structure of the Chemical Industry, Raw Materials and Energy Requirements (Fossil fuels, oleochemicals and biomass, sulphuric acid, nitrogen, minerals, etc.), the role of sustainability, National and Global Trends in the Chemical Industry, Raw materials and principals involved in producing olefins, aromatics, and novel developments in olefin production technology.

UNIT II ORGANIC INDUSTRIES 1 **14 h**

Important derivatives from olefins and aromatics as building blocks: petrochemical derivatives of C1, C2, C3, C4 olefin compounds and Aromatics

UNIT II ORGANIC INDUSTRIES 2 AND INORGANIC INDUSTRIES 1 **11 h**

Biotech Industry (esp. ethanol, biobutanol, etc.), Bio-refinery and Process for biomass conversion*, Production useful chemicals from Oleochemical feedstocks, Biodiesel and biofuel production, Glycerol valorisation, Cellulosic derivatives using conventional and process intensification approach,

Inorganic Chemicals: sulphuric acid, Nitric acid, Hydrochloric acid, Phosphoric acid.

UNIT IV INORGANIC INDUSTRIES 2 **10 h**

Nitrogen Industries: Manufacturing of ammonia, Nitrogenous, and Mixed fertilizers; Urea, Ammonium sulphate, Ammonium nitrate etc

Chlor–Alkali Industries*: Caustic soda and technological developments, Chlorine, Hydrochloric acid, Soda ash. and Sodium bicarbonate.

Note: *Brief overview of organic process industries, including raw materials, manufacturing of important products, properties, and applications*

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Define, identify, and select basic raw materials used for processes carried out in chemical industry

CO2 : Illustrate process flow diagrams/process block diagrams for the manufacture of various chemicals from the process description

CO3 : Identify different unit operations and unit processes with their significance in the process

CO4 : Analyse the technological options for problem-solving in process industries

CO5 : Recognize the importance of process economics in the industry

CO6 : Discuss the impact of professional engineering solutions for societal benefits

TEXT/REFERENCE BOOKS

1. J A Moulijn, M Makkee, A E. Van Diepen, Chemical Process Technology, 2nd edition, Wiley, 2013
2. I D Mall, Petrochemical Process Technology, Macmillan India Pvt ltd, 2007
3. O P Gupta, Elements of Chemical Process Technology, Khanna Publishing House, 2020
4. B K Bhaskar Rao, A textbook on Petrochemicals, Khanna Publishers, 2007
5. M. Gopala Rao, M Sitting, Dryden's Outlines of Chemical Technology, 3rd edition, East-West Press, 1997
6. G T. Austin, Shreve's Chemical Process Industries, 5th edition, McGraw Hill, 1984
7. Kirk-Othmer, Encyclopaedia of Chemical Technology, 3rd edition, John-Willey, 1981

Teaching Scheme					Chemical Process Technology Lab 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 apply the basics of chemical process equipment design into a simulation
2. To understand the sizing fundamentals of process design of equipment
3. To analyze the equipment designs for different evaluation criteria for various application
4. To provide students with hands-on training on the computational tools for equipment design

LIST OF EXPERIMENTS

1 Introduction to Laboratory, personal safety, and material handling.
2 To prepare Anthraquinone from Anthracene.
3 Analysis of Na_2CO_3 and $NaHCO_3$ mixture.
4 To prepare soap in the laboratory and to carry out its cost analysis.
5 To evaluate the saponification value of given oil sample.
6 To determine the acid value of given oil samples.
7 To prepare caustic soda by chemical method.
8 Analysis of bleaching powder.
9 Determination of the Sodium Carbonate in the Washing Soda.
10 To prepare hydrated lime from the given calcium carbonate powder.
11 Synthesis of Biodiesel using edible/nonedible oil.
12 Estimate the Fuel properties of prepared Biodiesel.
13 To synthesis caustic soda by electrochemical method.

COURSE OUTCOMES

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

CO1 : Able to find practical relevance of chemical process technology theory
CO2 : Illustrate the preparation methods of organic and inorganic compounds involving reactions, separation, and purification -techniques
CO3 : Characterize organic and inorganic compounds involving reactions, separation, and purification -techniques
CO4 : Analyse the results related to important compounds synthesised and purified
CO5 : Explain the impact of hazardous chemicals on environment
CO6 : Discuss the safety required for the chemical laboratories

TEXT/REFERENCE BOOKS

1. Chemical Process Technology Laboratory manual.
2. S Ray, G Das, Process Equipment and Plant Design: Principles and Practices, 1st edition, Elsevier Science, 2020.
3. S B Thakore and B I Bhatt, Introduction to Process Engineering and Design, Tata McGraw Hill, 2nd ed., 2018.
4. R K Sinnott, Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design, 2nd edition, Butterworth Heinemann, 2015.
5. Ludwig's Applied Process Design for Chemical and Petrochemical plants, Vol. 1 to 3, Gulf Publishing Company, 2011.
6. Illustrated Process Equipment Design by S B Thakore, 2nd edition, McGraw Hill, 2021.

UG Curriculum (2024 onwards)

Semester 5

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 5	OE		Open Elective 2 (NPTEL/SWAYAM/MOOC)	3	0	0	3	3
	HSC		Engineering Economics	3	0	0	3	3
	PE		Program Elective 1	3	0	0	3	3
			Petroleum Refining & Petrochemicals					
			Renewable Energy Engineering					
			Sustainability & Green Chemistry					
	PC		Mass Transfer 1	3	0	0	3	3
	PC Lab		Mass Transfer 1 Lab	0	0	2	2	1
	PC		Chemical Reaction Engineering 1	3	0	0	3	3
	PC Lab		Chemical Reaction Engineering 1 Lab	0	0	2	2	1
	PC		Process Equipment Design	3	0	0	3	3
	PC Lab		Process Equipment Design Lab	0	0	2	2	1
				18	**0**	**6**	**24**	**21**

					Petroleum Refining and Petrochemicals					
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 the fundamental understanding of units involved in petroleum refinery & petrochemical industry.
2. To understand the operation and importance of various conversion processes employed in refinery.
3. To discuss the various characterization techniques and testing methods of different petroleum fractions
4. To understand the manufacturing processes & applications of widely used petrochemicals.

UNIT I EVALUATION AND CHARACTERISATION OF CRUDE OIL AND PETROLEUM PRODUCTS **8 h**

Origin and occurrence, status of Indian petroleum industries, Pre-treatment of crude oil for refining, Petroleum Processing data- Evaluation of petroleum, Thermal Properties of petroleum fractions, Characterization of crude oil and product specification.

UNIT II PRETREATMENT AND FRACTIONATION OF CRUDE OIL **10 h**

Dehydration and desalting of crudes, Fractionation of petroleum through atmospheric and vacuum distillation, Heating of crude-Pipe still heaters, Treatment techniques for impurities in various fractions.

UNIT III THERMAL AND CATALYTIC PROCESSES FOR PRODUCT UPGRADATION **14 h**

Thermal and catalytic processes: Thermal cracking, Catalytic cracking, Fluidized Catalytic Cracking, Catalytic Reforming, Thermal Reforming, Coking technology, Hydrogen Processes-Hydrocracking, Hydro treatment, Hydrodesulphurization, Alkylation, Isomerisation Processes.

UNIT IV PROCESS TECHNOLOGY OF PETROCHEMICAL PRODUCTS **10 h**

Indian petrochemical industry overview, Petrochemical Industry feed stocks, Synthesis gas and chemicals, Petrochemicals derived from C1, C2, C3, C4, and BTX aromatics, Synthetic fibres, Shale Gas, Gas Hydrates, Coal bed Methane, manufacturing technologies for C1, C2, C3, C4, and aromatics compounds.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Outline the crude composition, properties, and characterization methods of different petroleum fractions.
CO2 : Understand the fractionation process of crude oil.
CO3 : Determine the different conversion processes of the heavier fractions by cracking and coking technology
CO4 : Illustrate the process technology of product upgradation units and Hydrogen processes.
CO5 : Review the treatment processes for preparing finished products using chemical or physical separation
CO6 : Facilitate the process technology of various important petrochemicals products

TEXT/REFERENCE BOOKS

1. J.H.Garry, G.E.Handwerk, M.J.Kaiser, Petroleum Refining Technology and Economics, CRC Press
2. B.K. Bhaskara Rao, Modern Petroleum Refining Processes, Oxford & IBH
3. Speight, J. G., The Chemistry and technology of Petroleum, 5th edition, M. Dekker, 1991.
4. W.L. Nelson, Petroleum Refining Engineering, Mc Graw- Hill

					Renewable Energy 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. 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 I Solar Energy Technologies **12 h**

Solar Radiation, Photovoltaic (PV) Technology, PV Cell Materials and Fabrication Techniques, Solar Thermal Energy Conversion Systems, Concentrating Solar Power (CSP) technologies, Design and Performance Analysis of PV and CSP Systems, Integration of Solar Energy Systems into the Grid

UNIT II Wind and Hydropower Systems Engineering **10 h**

Wind Turbine Technology and Aerodynamics, Wind Resource Assessment and Wind Farm Design
Hydropower System Components and Design, Tidal and Wave Energy Conversion Mechanisms, Environmental Impact and Sustainability Considerations

UNIT III Bioenergy and Geothermal Energy Systems **10 h**

Biomass Energy Sources and Conversion Technologies, Biofuels Production and Waste-to-Energy Systems, Geothermal Heat Extraction and Power Generation, Ground-Source Heat Pumps and Direct Use Applications, Environmental Impact and Resource Management

UNIT IV Smart Grids, Energy Storage, and Policy **10 h**

Smart Grid Technologies and Renewable Integration, Energy Storage Solutions: Batteries, Fuel Cells, and Mechanical Systems, Energy Policy, Economics, and Market Mechanisms, Regulatory Framework and Incentives for Renewable Energy, Case Studies in Renewable Energy Implementation and Best Practices

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Acquire in-depth expertise in the latest renewable energy technologies.
CO2 : Develop skills to design and optimize advanced renewable energy systems for grid integration.
CO3 : Critically assess and apply the latest energy storage technologies to enhance system reliability.
CO4 : Proficiently evaluate the environmental impact and sustainability of renewable energy systems.
CO5 : Understand and strategize the legal and economic frameworks for renewable energy systems.
CO6 : Conduct innovative research and advance knowledge in renewable energy engineering.

TEXT/REFERENCE BOOKS

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

					Sustainable and Green Chemistry					
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 the fundamental philosophy and the" basics importance of sustainability and green chemistry
2. To understand principles, synthesis methods, applications, and the latest developments in sustainable chemistry
3. To acquaint with various green reaction pathways of conventional reaction with real-world applications
4. To understand the necessity for solvent replacement options and new process development options available.

UNIT I SUSTAINABILITY AND NEED OF GREEN CHEMISTRY **7 h**

Chemistry- from past to future, importance of sustainability, need of green chemistry. Fundamentals of sustainable development, growth, consumption and natural wealth, sustainable development at different scales.

UNIT II GREEN CHEMISTRY **14 h**

Green Chemistry: - Principles and applications, Synthesis and Green Chemistry: Micro-reactor technology, Solvent-less reactions, Use of green solvents, brief about Combinatorial chemistry and role of AI in chemistry.

UNIT III GREEN SOLVENTS AND SOLVENT SELECTION **11 h**

Alternate Solvent: Green solvents, Water as a solvent; Amphiphilic compounds., Conventional Process and Operations- Current status and modification; Industrial Solvent Selection approaches

UNIT IV NEW DEVELOPMENTS AND INTRODUCTION TO LCA **10 h**

New Development Process: Overview of green separation processes, distillation, chromatography, fluid extraction, membrane processes, pressurized hot water extraction, nanotechnology in separation. Life Cycle Assessment of the Technology/ product, Industrial and research Case studies in Green synthesis.

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : How sustainability and green chemistry are useful in Chemical Engineering.
- **CO2** : Relate the concept of green solvents to minimize environmental concerns.
- **CO3** : Utilize green chemistry principles, application, and synthesis methods to identify the application of compounds.
- **CO4** : Categorize conventional process for solvent alternatives and operations.
- **CO5** : Importance of learning new sustainable development in various processes.
- **CO6** : Develop the techniques and learn the significance of the Life Cycle Assessment application.

TEXT/REFERENCE BOOKS

1. Vinod Kumar Garg, Anoop Yadav, Chandra Mohan, Sushma Yadav, Neeraj Kumari (Eds.) Green Chemistry Approaches to Environmental Sustainability: Status, Challenges and Prospective, 1st edition, Elsevier, 2023.
2. Anne E. Marteel-Parrish, Martin A. Abraham, Green Chemistry and Engineering: A Pathway to Sustainability, Wiley-AIChE, 2013.
3. Doble M. and Kruthiventi A. K., Green Chemistry and Processes, Academic Press, 2007.
4. Afonso C. A. M., Crespo J. G., Green Separation Processes, Wiley-VCH Verlag GmbH & Co., 2005.
5. Clark J., McQuarrie D., Handbook of Green Chemistry and Technology Blackwell Series, 2002.
6. Atkinson G., Dietz S., Neumayer E., Handbook of Sustainable Development Edward Elgar Publishing Limited, 2007.

UG Curriculum (2024 onwards)

					Mass Transfer 1					
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. Understanding of fundamentals of mass transfer like diffusion, mass transfer theories and mass transfer coefficient.
2. Examine the various mass transfer theories.
3. Apprehend the concept of transfer units.
4. Application of the interphase mass transfer concept.

UNIT I INTRODUCTION TO MASS TRANSFER OPERATIONS **12 h**

Fick's Law of diffusion, equimolecular counter diffusion in fluids, diffusion in stationary gas, Diffusion through variable cross-sectional area, Diffusion coefficient, Multicomponent diffusion, Diffusivity in solids

UNIT II MASS TRANSFER COEFFICIENTS **10 h**

Introduction to mass transfer coefficient, Correlation for convective mass transfer coefficient, Mass transfer equilibrium, Theories of mass transfer, Local and overall mass transfer coefficients, Steady state co and counter current processes, Material balance, Stage efficiency.

UNIT III ABSORPTION **10 h**

Equilibrium solubility of gases, Material balance for transfer of one component, Counter current multistage operations for binary and multi component systems, Continuous contactors, Absorption with chemical reaction, Concept of HTU and NTU, Equipment for Gas–Liquid operations

UNIT IV ADSORPTION **10 h**

Introduction, Adsorption isotherm, heat of adsorption, Selection of adsorbent, batch adsorption, Rate of adsorption in fixed beds, Adsorption Equipment, Adsorption dynamics, Regeneration of adsorbent, Thermal and pressure swing adsorption.

Maximum 42 hours

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 : Define the basic principles of diffusion, mass transfer theories and interphase mass transfer
CO2 : Explain the principles of diffusion and mass transfer operations like adsorption, absorption and stripping
CO3 : Apply principles related to diffusion, adsorption and absorption.
CO4 : Analyze the problems related to diffusion, adsorption and absorption.
CO5 : Justify the applications of theory learned in industrial practices regarding diffusion, adsorption and absorption.
CO6 : Design columns related to diverse mass transfer operations like adsorption and absorption.

TEXT/REFERENCE BOOKS

1. R.E. Treybal, Mass Transfer Operations, 3rd edition, McGraw Hill Education
2. B. K. Dutta, Principle of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006
3. K. V. Narayanan, Mass Transfer: Theory and Applications, CBS Publishers, 2005
4. P. C. Wankat, Separations in Chemical Engineering: Equilibrium Staged Separations, Prentice Hall, NJ, US, 1988.
5. J. M. Coulson and J. F. Richardson, Particle Technology and Separation Processes, 5th edition, Elsevier, 2006
6. W. L. McCabe and J. C. Smith, Unit Operations of Chemical Engineering, 7th edition, McGraw Hill Education, 2014.

					Mass Transfer 1 Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Understand and learn to quantify the diffusivity and mass transfer coefficient.
2. Understand the principle of pressure and temperature swing adsorption.
3. Understand and learn the principles of adsorption and absorption.
4. Application of mass transfer theories to characterize packed beds and sieve tray for mass transfer.

SR.	LIST OF EXPERIMENTS
1	To study the absorption of carbon dioxide by aqueous sodium hydroxide solution in a packed bed column.
2	To study solid in air diffusion using a packed bed of spherical particles of naphthalene.
3	To determine the diffusion co-efficient of any liquid in air & it's variation with temperature.
4	To study the absorption of carbon dioxide by aqueous sodium hydroxide solution in a sieve tray column.
5	To study the absorption of carbon dioxide by aqueous sodium hydroxide solution in a wetted wall tower.
6	To study the batch adsorption of acetic acid by activated carbon and then test the validity of certain adsorption isotherm.
7	To study the adsorption in a packed bed for a solid liquid system.
8	To determine mass transfer coefficient in interphase mass transfer.

COURSE OUTCOMES

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

CO1 : Define the diffusivity, mass transfer coefficient and isotherms.
CO2 : Explain the extent of mass transfer
CO3 : Apply principles related to diffusion, absorption, and adsorption.
CO4 : Distinguish the effectiveness of packed bed, empty column, and sieve tray.
CO5 : Determine the diffusivity and mass transfer coefficient in different type of systems.
CO6 : Estimate the extent of mass transfer and constants of different isotherms.

TEXT/REFERENCE BOOKS

1. Mass Transfer Laboratory Manual
2. R.E. Treybal, Mass Transfer Operations, 3rd edition, International Student Edition, McGraw Hill Education
3. W. L. McCabe, J. Smith, and P. Harriott - Unit operations of Chemical Engineering, 7th edition, McGraw-Hill international edition, 2005
4. B. K. Dutta, Principle of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006
5. K. V. Narayanan, Mass Transfer: Theory and Applications, CBS Publishers, 2005
6. P. C. Wankat, Separations in Chemical Engineering: Equilibrium Staged Separations, Prentice Hall, NJ, US, 1988.

					Chemical Reaction Engineering 1					
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 understanding of basic principles and terminology in reaction kinetics
2. To acquaint students towards basic designing of ideal reactors
3. To allow students to analysis the rate data and thereby find the kinetics parameters of interest.
4. To illustrate concept of reactor sequencing and evaluate the performance of ideal reactors.

UNIT I BASICS OF KINETICS **10 h**

Mole balances, kinetics of homogeneous reactions – rate of reaction, type of reactions, reaction mechanism, temperature and concentration dependent term of a rate equation, searching for a reaction mechanism, rate law and stoichiometry, concentration and conversion change, introduction to batch and continuous reactor systems, sizing and characteristics of reactors.

UNIT II ANALYSIS OF RATE DATA **12 h**

Collection and analysis of rate data, integral and differential method of analysis of data, batch reactor data, variable and constant volume system, method of initial rates, method of half-life, differential reactors, least square analysis.

UNIT III ISOTHERMAL REACTOR DESIGN **10 h**

Ideal reactors: batch reactors, semi-batch reactors, continuous-flow reactors (MFR & PFR), recycle reactors conversion and reactor sizing, design equations, applications of the design equations for continuous-flow reactors, steady and unsteady operation of ideal reactors

UNIT IV REACTOR SEQUENCING **10 h**

Reactors in series, reactors for parallel reactions, maximizing desired product in parallel reactions, maximizing desired product in series reactions, temperature and pressure effect in single and multiple reactions, adiabatic reactor design, criteria for reactor selection and its operating conditions

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Relate to the basics of kinetics and basic theories to get the underlying mechanisms
CO2 : Interpret and evaluate the rate data and get the kinetics parameters
CO3 : Select proper design equations and perform reactor sizing for ideal reactors
CO4 : Examine the suitable combinations of ideal reactors for optimal performance
CO5 : Decide the reactor sequencing for single and multiple reactions towards desired products
CO6 : Evaluate reactor systems and recommend best suitable reactor and its operating conditions

TEXT/REFERENCE BOOKS

1. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd edition, New Delhi-Prentice Hall, 2001
2. O. Levenspiel, Chemical Reaction Engineering, Willey Eastern, 3rd edition, 2000
3. J. M. Smith, Chemical Engineering Kinetics, 3rd edition, McGraw- Hill, 1988
4. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 1998

					Chemical Reaction Engineering 1 Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Experimentation with different ideal reactors for a homogeneous liquid phase reactions to determine kinetics.
2. To find the kinetic parameter using Arrhenius theory by experimentation with different ideal reactors.
3. Experimentation with combination of ideal reactors and analyse the performance optimization.
4. Find the application of combination of ideal reactors and the change in performance with the ideal reactors.

SR.	LIST OF EXPERIMENTS
1	To study a non-catalytic homogeneous liquid phase reaction in an ambient CSTR
2	To study a non-catalytic homogeneous liquid phase reaction in an ambient straight tube PFR
3	To study a non-catalytic homogeneous liquid phase reaction in an ambient semi-batch reactor
4	To study a non-catalytic homogeneous liquid phase reaction in an ambient three Cascaded CSTR
5	Evaluating kinetic parameters (k_0 and E) for a saponification reaction in a batch reactor
6	To study a non-catalytic homogeneous liquid phase reaction in an ambient combined flow reactor (CSTR+PFR)
7	To perform saponification reaction for a pseudo first order reaction in a CSTR (M~25-50)
8	To perform saponification reaction for a variable molar ratio of reactants in a CSTR (M>1)

COURSE OUTCOMES

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

CO1 : Relate to the basics of kinetics and application of the same in practical
CO2 : Interpret and evaluate the rate data and get the kinetics parameters for different reactors
CO3 : Apply proper rate equations and compare the performance of different ideal reactors
CO4 : Examine the combinations of ideal reactors and analyse the theoretical findings
CO5 : Decide the reactor sequencing to optimize the volume or conversion for given combinations of reactors
CO6 : Develop an ability to work in group, learn report making, and improve soft skills in representing the findings

TEXT/REFERENCE BOOKS

1. Chemical Reaction Engineering Laboratory Manual
2. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd edition, New Delhi-Prentice Hall, 2001
3. O. Levenspiel, Chemical Reaction Engineering, Willey Eastern, 3rd edition, 2000
4. J. M. Smith, Chemical Engineering Kinetics, 3rd edition, McGraw- Hill, 1988
5. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 1998

					Process Equipment Design					
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 a fundamental understanding of various laws of thermodynamics.
2. To develop an understanding of the PVT behaviour of a pure component.
3. To derive various thermodynamic properties in terms of measurable variables.
4. To provide a framework for the phase behaviour of pure components and mixtures.

UNIT I DESIGN OF FLUID TRANSPORT EQUIPMENT **12 h**

Process design of piping, designs based on internal and external design pressures, Process design of Centrifugal pumps, fan, blower, and compressors, Piping networks, Fundamentals of Piping related Instrumentation (P&I).

UNIT II DESIGN OF HEAT TRANSPORT EQUIPMENT **10 h**

Process design of heat exchangers, shell & tube heat exchangers, the design method of shell & tube heat exchanger, General mechanical design considerations, Reboilers, Heat-exchanger networks.

UNIT III DESIGN OF MASS TRANSPORT EQUIPMENT **12 h**

Process design of tray-based distillation and absorption columns, process design & selection criteria for various internals, considerations in packed columns, Process design of a column network, general mechanical design considerations.

UNIT-III DESIGN OF CHEMICAL REACTORS **8 h**

Process design of chemical storage vessels and adiabatic and isothermal reactors, process design of reactors in batch, semi-batch, and continuous operations, general mechanical design considerations.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Explain the basics of chemical process equipment design
CO2 : Understand the international standards, fabrication, and testing methods
CO3 : Execute the sizing calculations of pipes, heat transfer and mass transfer equipment
CO4 : Understand the parametric interdependence and the need for the holistic design approach
CO5 : Critically analyse and combine the elements of various designs of process equipment
CO6 : Design the different types of equipment used in chemical process industries

TEXT/REFERENCE BOOKS

1. S Ray, G Das, Process Equipment and Plant Design: Principles and Practices, 1st edition, Elsevier Science, 2020.
2. S B Thakore and B I Bhatt, Introduction to Process Engineering and Design, Tata McGraw Hill, 2nd ed., 2018.
3. R K Sinnott, Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design, 2nd edition, Butterworth Heinemann, 2015.
4. Ludwig's Applied Process Design for Chemical and Petrochemical plants, Vol. 1 to 3, Gulf Publishing Company, 2011.
5. Illustrated Process Equipment Design by S B Thakore, 2nd edition, McGraw Hill, 2021.

					Process Equipment Design Laboratory					
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 apply the basics of chemical process equipment design into a simulation
2. To understand the sizing fundamentals of process design of equipment
3. To analyze the equipment designs for different evaluation criteria for various application
4. To provide students with hands-on training on the computational tools for equipment design

LIST OF EXPERIMENTS

1 Introduction to various Process Simulation Software and understanding of the modelling of unit operations
2 Process calculation and simulation for mixing streams using a pipeline network
3 Process calculation and simulation of pumping system for liquid streams
4 Process calculation and simulation of compressor/blower system
5 Process calculation and simulation on heat exchangers
6 Process calculation and simulation on multi-effect evaporators heat exchangers
7 Process calculation and simulation of distillation operation using McCabe and Thiele method
8 Process calculation and simulation of short-cut approaches for water-methanol separation using distillation
9 Process calculation and simulation of rigorous approaches for water-methanol separation using distillation
10 Process calculation and simulation of the absorption of acetic acid using water solvent

COURSE OUTCOMES

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

CO1 : Recall the basics of computer-aided software used in process calculations.
CO2 : Explain the methodology used in the design calculations.
CO3 : Apply the knowledge gained for the optimisation of a process variables.
CO4 : Analyse critically for the optimum design.
CO5 : Recommend the various internals needed in a chemical process.
CO6 : Design and develop the process flow diagrams.

TEXT/REFERENCE BOOKS

1. Process Equipment Design Laboratory manual.
2. S Ray, G Das, Process Equipment and Plant Design: Principles and Practices, 1st edition, Elsevier Science, 2020.
3. S B Thakore and B I Bhatt, Introduction to Process Engineering and Design, Tata McGraw Hill, 2nd ed., 2018.
4. R K Sinnott, Chemical Engineering Design Principles, Practice and Economics of Plant and Process Design, 2nd edition, Butterworth Heinemann, 2015.
5. Ludwig's Applied Process Design for Chemical and Petrochemical plants, Vol. 1 to 3, Gulf Publishing Company, 2011.
6. Illustrated Process Equipment Design by S B Thakore, 2nd edition, McGraw Hill, 2021.

UG Curriculum (2024 onwards)

Semester 6

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 6	OE		Open Elective 3 (Inter-department, FoET)	3	0	0	3	3
	PE		Program Elective 2	3	0	0	3	3
			Piping Design					
			Corrosion Engineering					
			Material Science & Engineering					
	PE		Program Elective 3	3	0	0	3	3
			Nano Technology & Energy Storage					
			Membrane Processes					
			Environmental Engineering and Pollution Control					
	PC		Instrumentation & Process Control	3	0	0	3	3
	PC Lab		Instrumentation & Process Control Lab	0	0	2	2	1
	PC		Mass Transfer 2	3	0	0	3	3
	PC Lab		Mass Transfer 2 Lab	0	0	2	2	1
	PC		Chemical Reaction Engineering 2	3	0	0	3	3
	PC Lab		Chemical Reaction Engineering 2 Lab	0	0	2	2	1
				18	**0**	**6**	**24**	**21**

Teaching Scheme					Piping Design					
					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. Create, select, and apply appropriate modern software tools for fluid flow and pipeline engineering.
2. Identify and learn the usage of proper fluid moving machines and pressure changers in a process plant.
3. Learn application and solve pipe flowsheeting problems more quickly, efficiently, and successfully using computer aided tools.
4. Understand pressure drops to maximize flow and mitigate the risk for flow assurance issues, Learn and analyse piping networks along with process equipment.

UNIT I PIPE FLOW HYDRAULIC ANALYSIS AND DESIGN **12 h**

Introduction to piping engineering, Basic of fluid flow through pipes (Newtonian and non-Newtonian fluids). Codes & standards for piping engineering & design Piping elements viz. pipes, fittings, flanges, gaskets, bolting, valves etc. Types of valves, Piping drawing layout and instruments diagram.

UNIT II PRESSURE CHANGERS **10 h**

Handling fluid streams to change its pressure for different reasons, pressures changers, pumps, compressors, valves etc. design and analysis using computational software, selection, and efficiency.

UNIT III PIPING NETWORK ANALYSIS **10 h**

Head losses due to contraction and expansion, other types of losses Network analysis, Overall loss estimation through network analysis, optimizing piping network with respect to losses, Hardy-Cross method, dynamic multi-phase pipeline modelling. Integrate pipeline models with processing facilities to conduct what-if analyses and optimizations.

UNIT IV INDUSTRIAL PIPING SYSTEM **10 h**

Piping for oil and gas industries, underground piping, Design of water handling piping system, sizing for equal velocity, sizing for equal areas, optimal sizing, water hammer, Steam piping design, stream traps, Slurry and sludge piping.

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Understand, create, select, and describe the design, codes, standard and specification in piping engineering.
- **CO2** : Understand the design and characteristics of different industrial valves.
- **CO3** : Estimate overall pressure drop and maximize flow by application of pipe fittings and pressure changers in piping system networks.
- **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 computational software.
- **CO6** : Outline process intensification and construct piping system networks.

TEXT/REFERENCE BOOKS

1. Juma Haydary, Chemical Process Design and Simulation, John Wiley & Sons, 2019.
2. Ed Bausbache and Rogur Hunt, Process Plant Layout and Piping Design, PTR Prentice Hall, 1993.
3. G.K. Sahu, Handbook of Piping Design, New age International Publishers, 1998.
4. E. Shashi Menon, Piping Calculation Manual, McGraw-Hill Education, 2005.

					Corrosion 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. Be introduced to the principles of the chemistry behind corrosion and the essential elements of electrochemical corrosion.
2. Lay a foundation for understanding the forms of corrosion, corrosion mechanisms, and electrochemical methods.
3. Analyse the vulnerability of engineering systems to the corrosion and the trailing losses.
4. Develop the engineering methods to prevent and control various forms of corrosion.

UNIT I INTRODUCTION AND FUNDAMENTALS OF CORROSION **12 h**

Definitions of Corrosion, Overall classification of types of corrosion, Basic electrochemistry, Galvanic, and electrolytic cells, Potential measurements, Galvanic corrosion, bimetallic contacts, Eh – pH diagrams, Electrode kinetics, Polarization phenomena, Polarization techniques to measure corrosion rates, Cost of Corrosion, Metallurgical properties influencing corrosion, General Testing procedures,

UNIT II TYPES OF CORROSION **10 h**

Uniform attack, Galvanic corrosion, Crevice corrosion, Pitting corrosion, Intergranular corrosion, Selective leaching, Erosion corrosion, Stress corrosion, Mechanisms, Testing procedures

UNIT III ELECTRO-CHEMICAL METHODS OF CORROSION PREVENTION AND CONTROL **10 h**

Mixed potential theory, Cathodic protection, stray current corrosion, Anodic control, Electrochemical coatings, speciality coatings and surface protection

UNIT IV MECHANO-CHEMICAL METHODS OF CORROSION PREVENTION AND CONTROL **10 h**

Design, Mechanical and non-electrochemical coatings, corrosion inhibition, Passivity phenomena and development of corrosion-resistant alloys.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Define the basics of corrosion and its various forms.
CO2 : Demonstrate the testing procedures for corroding systems.
CO3 : Apply the electrochemical and metallurgical aspects of combating eight forms of corrosion.
CO4 : Inspect the corrosion and provide the correct prevention and control method.
CO5 : Evaluate the vulnerability of any materialistic system to corrosion.
CO6 : Design a suitable system to withstand corrosion under the given conditions.

TEXT/REFERENCE BOOKS

1. M. G. Fontana, Corrosion Engineering, 3rd edition, McGraw-Hill Book Company.
2. Denny A Jones, Principles and Prevention of Corrosion, 1st edition, Prentice-Hall, 1996.
3. H. H. Uhlig and R. W. Revie, Corrosion and Corrosion Control, Wiley.
4. P. Roberge, Corrosion Engineering: Principles and Practice, 1st edition, McGraw-Hill, 2006.

					Material Science & 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 impart the basic concept of material science.
2. To understand the various properties, corrosion, and heat treatment of engineering materials
3. To understand the engineering requirement and selections of materials for various applications.
4. To gain knowledge of how machine learning is implemented for material synthesis.

UNIT I CRYSTAL STRUCTURE AND CHARACTERIZATION OF ENGINEERING MATERIALS **10 h**

Different categories of engineering materials, Selection of materials, Crystal structure Crystal geometry, Structure of solids, Methods of determining structures, Imperfection in crystals, Types of imperfection, Point imperfection, characterization of crystal structure through XRD, SAED pattern of TEM, UV-VIS, FTIR Spectroscopy, Raman Spectroscopy.

UNIT II PHYSICAL PROPERTIES OF ENGINEERING MATERIAL **12 h**

Mechanical, Electrical and magnetic properties of materials, Physical significance of dielectric permittivity, Electrical conductivity, Magnetic permeability, magnetic Susceptibility, Curie point, Deformation of materials, Heat Treatment techniques, Corrosion, Theories of corrosion, Control and prevention of corrosion, Economic Impact of corrosion in process industries, Consideration of Corrosion in engineering design.

UNIT III FERROUS AND NON-FERROUS MATERIALS FOR PROCESS INDUSTRIES **10 h**

Engineering materials: Ferrous metals, Iron and their alloys Iron and steel Iron carbon equilibrium diagram, Non-ferrous metals and alloys, Aluminium, Copper, Zinc, lead, Nickel and their alloys with reference to the application in chemical industries.

UNIT IV CERAMIC MATERIALS, NANOMATERIALS, AND THEIR APPLICATIONS **10 h**

Inorganic materials: Ceramics, Glass and refractories, organic materials: wood, plastics, and rubber and wood, Advanced materials (Biomaterials, nanomaterials, and composites) with special reference to the applications in chemical Industries. Nanoparticle synthesis, Application of nanomaterials in biomedical engineering, wastewater treatment, catalysis-photocatalysis, and environmental remediation, AI in advanced nanomaterial synthesis.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Understand the basics such as internal structure, crystal geometry, and imperfection of the engineering materials
CO2 : Explain various properties of material such as mechanical, electrical, and magnetic.
CO3 : Corrosion, remedial measures for corrosion, and its economic impact.
CO4 : Examine the various materials for their potential application in chemical industry.
CO5 : Predict material in chemical engineering in the areas of equipment design
CO6 : Several nanomaterials and their usage in diverse fields and AI based material synthesis

TEXT/REFERENCE BOOKS

1. Lawrence H. Van Vlack, Elements of Material Science and Engineering.
2. S. K. Hajra Choudhury, Material Science and processes, 1st edition, Indian Book Distribution Co., Calcutta.
3. William D. Callister, Materials Science and Engineering, 7th edition, John Wiley & Sons, Inc.
4. V. Raghavan, Materials Science and Engineering, Prentice Hall, 2004.

					Nano Technology & 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 nanotechnology.
2. Explain the nanoscale paradigm in terms of properties at the nano scale dimension.
3. Identify current nanotechnology solutions in design, engineering, and manufacturing.
4. To understand the use of nanotechnology in energy storage and other applications.

UNIT I INTRODUCTION TO NANOTECHNOLOGY **12 h**

Introduction to nanotechnology, history of nanotechnology, nanotechnology perspective – world & India, nano size and properties, classification of nanostructures, defects in nanomaterials, applications of nanomaterials – brief, properties of nanomaterials – bulk to nano, nanomaterial case studies demonstrating non-classical behaviour at nanoscale in successful and emergent nanotechnologies

UNIT II SYNTHESIS OF NANOMATERIALS **10 h**

Synthesis of nano materials, bottom-up approach: self-assembly and self-organization, vapor phase deposition, colloidal, sol-gel, simple pyrolysis, top-down approach: miniaturization of smaller structures from larger ones like milling, lithography, machining will be presented with suitable examples, synthesis by templating methods, soft templating and hard templating, hydrothermal and solvothermal process, microwave assisted synthesis

UNIT III CHARACTERIZATION OF NANOMATERIALS **08 h**

Detailed characterization technique based on radiation matter interactions and their analytical applications like Transmission electron microscope, scanning electron microscope, atomic force microscope, scanning tunnelling microscope, X-ray diffraction, Small Angle X-Ray, Dynamic light scattering, Spectroscopies, Infra-Red Spectroscopy & FTIR, UV-Vis Spectroscopy, Raman Spectroscopy, Surface Area Analysis, Safety during handling of characterization equipment

UNIT IV NANOMATERIALS FOR ENERGY AND VARIED APPLICATIONS **12 h**

Nanomaterials applications to catalysis, food and agriculture, semiconductor and electronics, structural materials, water treatment and environment, medical devices, drug delivery, paints, textile and defense equipment's. Nanotechnology for sustainable energy, materials for light emitting diodes, batteries, advanced turbines, capacitors, fuel cells, nano technology enabled renewable energy technologies, energy transport, conversion and storage, nano, micro and meso scale devices.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Understand the basics of Nanotechnology, its terminologies, and unique properties.
CO2 : Explain in detail the physical and chemical methods for synthesis of nanoparticles.
CO3 : Develop various nanomaterials understanding the requirement of application and properties
CO4 : Compare various techniques for nano-materials characterization and interpretation of results.
CO5 : Evaluate the characterization results for the standard nanoparticles.
CO6 : Discuss, build, & propose novel solutions on the use of nanotechnology in varied applications.

TEXT/REFERENCE BOOKS

1. Kelsall et al, Nanoscale Science and Technology, John Wiley & Sons
2. Stuart M. Lindsay, Introduction to Nanoscience, Oxford University Press
3. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Capital Publishing Company
4. BS Murty et al., Textbook of Nanoscience and Nanotechnology, Springer - Universities Press (India) Private Limited

					Membrane Processes					
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. Acquire in-depth knowledge in different types of membranes, materials, and transport mechanism.
2. To understand various membrane fabrication techniques and their characterization methods.
3. To learn membrane modules for effective application in different membrane-based processes.
4. To develop the understanding of concentration polarization and membrane fouling.

UNIT I MEMBRANE OVERVIEW AND TRANSPORT THEORY **10 h**

Historical Development of Membranes, Membrane materials, polymeric, inorganic and liquid, Isotropic Membranes, Anisotropic Membranes, Inorganic Membranes, Liquid Membranes, Pore flow model, Solution-Diffusion Model, Structure-Permeability Relationships.

UNIT II MEMBRANE FABRICATION TECHNIQUES AND MODULES **10 h**

Membrane preparation: phase inversion, immersion precipitation, solution evaporation, track-etch method, sol-gel process, interfacial polymerization, dip-coating process, film stretching and template leaching, etc. Membrane Modules-hollow fiber, spiral wound, flat sheet, etc.

UNIT III MEMBRANE CHARACTERIZATION **10 h**

Membrane characterization- Morphology, top surface and cross-section structure, surface properties, hydrophilicity and hydrophobicity, porosity, water flux, permeability, pore size, FTIR analysis, solute rejection properties, protein adsorption property, etc.

UNIT IV MEMBRANE PROCESSES AND FOULING **12 h**

Reverse osmosis, Nanofiltration, Ultrafiltration, Microfiltration, Gas separation, Membrane distillation, Membrane bioreactors, etc. Concentration Polarization in Liquid Separation Processes, Gel Layer Model, Osmotic Pressure Model, Boundary Layer Resistance Model, Membrane Fouling, Fouling Control.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Define the basic knowledge of membranes, materials, types, and transport mechanism.
CO2 : Illustrate skills in the areas of fabrication of isotropic and anisotropic membranes.
CO3 : Identify the different membrane modules and demonstrate the skills in the characterization techniques.
CO4 : Examine the mechanism of concentration polarization and membrane fouling.
CO5 : Assess transport models in membrane separation processes.
CO6 : Estimate the membrane performance and separation characteristics of different processes.

TEXT/REFERENCE BOOKS

1. R. W. Baker, Membrane Technology and Applications, 2nd edition, WILEY
2. A.F. Ismail and T. Matsuura, Membrane Separation Processes, 1st edition, Elsevier.
3. A.F. Ismail, M. A. Rahman, Membrane Separation Principles and Applications, 1st edition, Elsevier.
4. Kaushik Nath, Membrane Separation Processes, PHI learning.

					Environmental Engineering and Pollution Control					
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 environmental regulations and standards.
2. To understand the principles and designing of air pollution control devices.
3. To discuss the characteristics and treatment methods of water and wastewater.
4. To understand the solid waste management and noise pollution control.

UNIT I ENVIRONMENTAL STANDARDS AND AIR POLLUTION CONTROL **11 h**

Classification of pollutants and their permissible limits, Air Pollutant Concentration Calculations, Air Quality Index, Air pollution control: settling chamber, cyclone separators, dust collector, fabric filters, venturi scrubbers, electrostatic precipitators, wet scrubber, adsorption, absorption, Catalytic reduction eg. SCR.

UNIT II PRELIMINARY AND PRIMARY TREATMENT PROCESSES **11 h**

Sources of water, Impurities in water, Indian & WHO standards for drinking water, Water borne diseases and theircontrol, Sources of wastewater, Physical, chemical, and biological characteristics of water and wastewater, Water Quality Index Calculation, Preliminary treatment processes: Screens, Skimming process. Primary treatment processes: Sedimentation, Coagulation and flocculation, Sand filtration.

UNIT III SECONDARY AND TERTIARY TREATMENT PROCESSES **10h.**

Primary treatment processes: Activated Sludge Process- design procedures for HRT, F/M ratio, SVI, MLSS, sludge age, Trickling filters, and their efficiency: standard, high rate and two-stage, Sludge treatment: sludge digestion process. Tertiary Treatment Processes: Disinfection, Membrane processes, Adsorption, and ion exchange, ozonation, Aeration, Softening, fluoridation, Decarbonation, Lime soda softening, Demineralization.

UNIT IV SOLID WASTE MANAGEMENT AND NOISE POLLUTION CONTROL **10 h**

Solid Waste Management: Quantity, Composition and characteristics of solid waste, Methods of solid waste treatment and disposal. Treatment of plastic and e-waste. Noise Pollution: level and standards, Effects, and control.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Define environmental regulatory legislations & standards and various types of pollution.
CO2 : Demonstrate different types of waste generated, disposal methods, reduce and monitoring process.
CO3 : Solve design calculations for air pollution control devices.
CO4 : Analyse the properties of water and wastewater.
CO5 : Assess pollution control in air and treatment processes of water, wastewater, and solids.
CO6 : To acquire knowledge about the various environmental and safety standards and legislations

TEXT/REFERENCE BOOKS

1. C. S. Rao, Environmental Pollution Control Engineering.
2. H. S. Peavy, Environmental Engineering, McGraw-Hill, International Edition,1985.
3. Wastewater Engineering: Treatment & Reuse by Metcalf and Eddy, McGraw Hill Publication.
4. Pollution control in process industries, S P Mahajan, Tata McGraw Hill Publishing Company.

					Instrumentation and Process Control					
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 Laplace transformation method to solve differential equations.
2. To provide a fundamental understanding of process control using the Transfer function approach.
3. To develop an understanding of various control actions such as P, PI, and PID controllers.
4. To understand the working of the most common instruments used in chemical industries.

UNIT I: INTRODUCTION **10 h**

Introduction and Motivation to do process control, Block diagram representation, Input-output model of a process, Time and Frequency domain representation of processes, Laplace transform, Inverse Laplace transform, and Transfer functions, different types of input functions- delta, step, ramp, sinusoidal etc., defining piecewise continuous functions in terms of step input.

UNIT II: PROCESS MODELING AND CONTROLLERS **10 h**

First-order systems, Linearization, Second-order systems, Stability analysis using system poles, Routh's stability test, Feedback control, Introduction of P, PI, PID controllers, Servo & Regulatory control, Simplification of complex block diagrams, Cascade control.

UNIT III: FREQUENCY DOMAIN ANALYSIS **10 h**

Frequency-domain analysis: Amplitude ratio and phase, Bode stability criterion, Bode plots of Simple gain, Integrator, Differentiator, first-order-lag, and first-order lead systems. Controller tuning – stability-based tuning, direct synthesis methods of tuning, Problem of inverse response, and dead time in processes.

UNIT IV: INSTRUMENTATION **12 h**

Transducers and their dynamics, Temperature measurement: Resistance temperature device, thermocouples, thermistors; Pressure measurement: Manometers, diaphragms, capsules and bellows, Bourdon tubes, Flow measurement, and Level measurement.

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Identifying an appropriate measuring instrument for the quantities such as Temperature, Flow, Pressure, and Liquid-level.
- **CO2** : Understanding the process control systems from an input-output point of view using block diagrams.
- **CO3** : Apply Laplace transformations and inverse Laplace transformations to find the response of a process.
- **CO4** : Analyse the Feedback control strategy using Proportional (P), Proportional-Integral (PI), and Proportional-Integral-Derivative (PID) control actions.
- **CO5** : Evaluate the stability of a process using system poles and Bode analysis.
- **CO6** : Build an appropriate controller by incorporating various controller tuning methods.

TEXT/REFERENCE BOOKS

1. Donald R. Coughanowr and Steven E. LeBlanc, Process Systems Analysis and Control, 3rd edition, McGraw Hill Education, 2017.
2. George Stephanopoulos, Chemical Process Control, Prentice-Hall India Learning Pvt. Ltd., 2008.
3. Ernest O. Doebelin, Measurement Systems – Application and Design, 4th edition, McGraw-Hill, 1990.

					Instrumentation and Process Control Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. To study the transient response of first and second-order systems for step and impulse change in inputs.
2. To study the interacting and non-interacting series connections of liquid-level systems.
3. To study the working and calibration of RTD, Thermocouple, and Thermistors.
4. To study the pressure control and cascade control systems.

SR. LIST OF EXPERIMENTS

1 Study of Control valve characteristics.
   a. Study of inherent installed characteristics of Control valves.
   b. Study of installed characteristics of Control valves.

2 Study of hysteresis in control valves.
3 Study of Step response of a single-capacity system
4 Study of the transient response of a non-interacting tank system.
5 Study of the transient response of an interacting tank system.
6 Temperature measurement using Bimetallic and Mercury-in-glass thermometers.
7 Temperature measurement using RTD, Thermocouple, and thermistors.
8 Study of a flapper-nozzle system.
9 Study of Step response of a second-order system using a mercury U-tube manometer.
10 Study of P, PI, and PID controllers using a multi process trainer.
11 Study of a cascade control system.
12 Study of a pressure control system.

COURSE OUTCOMES

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

CO1 : Identifying the control valves using there flow characteristics.
CO2 : Understanding the transient response of the first and second-order processes.
CO3 : Determine the transfer function parameters of first and second-order processes.
CO4 : Calculating the gain of a flapper-nozzle system, glass and bimetallic thermometers.
CO5 : Validate the experimental data from the Thermocouple, RTD, and thermistor against the standard data.
CO6 : Adapting P, PI, and PID control mechanisms to control level, flow, and pressure,

TEXT/REFERENCE BOOKS

1. Instrumentation and Process Control Laboratory Manual
2. Donald R. Coughanowr and Steven E. LeBlanc, Process Systems Analysis and Control, 3rd edition, McGraw Hill Education, 2017.
3. George Stephanopoulos, Chemical Process Control, Prentice-Hall India Learning Pvt. Ltd., 2008.
4. Ernest O. Doebelin, Measurement Systems – Application and Design, 4th edition, McGraw-Hill, 1990.

					Mass Transfer 2					
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 the principle of liquid-liquid and solid-liquid operations and the principle of vapour liquid equilibria.
2. Examine the importance of humidification and dehumidification for cooling purpose in industries.
3. Identifying the engineering problems involving extraction, adsorption, humidification, and dehumidification and drying.
4. Applying the concept of number of transfer unit concept in cooling tower.

UNIT I DISTILLATION **12 h**

Vapour liquid equilibria, Types of Distillation, Binary systems, Mc-Cabe Thiele and Ponchon-Savarit method, Calculations with multiple feeds and withdrawal, Azeotropic and extractive distillation, Multi component distillation concept.

UNIT II EXTRACTION **10 h**

Introduction to liquid-liquid extraction, liquid-liquid equilibrium, types of co-ordinate systems, solvent selection, stage wise extraction, liquid-liquid extraction equipment, selection of extractors, Principle and theory of solid liquid extraction, types of operations, single and multistage operations.

UNIT III HUMIDIFICATION AND DEHUMIDIFICATION **10 h**

Terminology and definitions, Psychometric charts and measurement of humidity, Classification of cooling tower, Cooling tower calculations, evaporative cooling, types of cooling tower and dehumidification methods.

UNIT IV DRYING AND CRYSTALLIZATION **10 h**

Drying equilibrium and rate of drying, calculation of drying time, drying operation batch and continuous, types of dryers and selection criteria. Crystallization: Solid-liquid phase equilibrium, nucleation and crystal growth, principles of super saturation, types of industrial crystallizers

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Define the basic principles of mass transfer operations like extraction, distillation, drying, humidification, and dehumidification.
- **CO2** : Explain the principles of mass transfer operations like extraction, distillation, drying, humidification, and dehumidification.
- **CO3** : Apply principles related to extraction, distillation, drying, humidification, and dehumidification.
- **CO4** : Analyse the problems related to extraction, distillation, drying, humidification, and dehumidification.
- **CO5** : Justify the applications of theory learned in industrial practices regarding extraction, distillation, drying, humidification, and dehumidification.
- **CO6** : Design mass transfer equipment based upon the conditions given in the problem statement.

TEXT/REFERENCE BOOKS

1. R.E. Treybal, Mass Transfer Operations, 3rd edition, International Student Edition, McGraw Hill Education
2. B. K. Dutta, Principle of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006
3. K. V. Narayanan, Mass Transfer: Theory and Applications, CBS Publishers, 2005
4. P. C. Wankat, Separations in Chemical Engineering: Equilibrium Staged Separations, Prentice Hall, NJ, US, 1988.

					Mass Transfer 2 Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Understand the principle of liquid-liquid and solid-liquid operations.
2. Learn the application simple distillation, steam distillation and fractional distillation.
3. Explain the application of distillation, extraction, drying, and crystallization operation.
4. Formulate and solve engineering problems involving drying, distillation, extraction, humidification, and dehumidification.

SR.	LIST OF EXPERIMENTS
1	To study the effect of phase ratio on extraction of acetic acid (dispersed phase) by ethyl acetate (continuous phase).
2	To find out the number of stages required for extraction of acetic acid (dispersed phase) by ethyl acetate (continuous phase).
3	To study solid liquid extraction in batch process and hence find out the effect of solvent temperature on the percentage recovery of oil from oil seeds.
4	To determine the yield of benzoic acid crystal.
5	To Find Out the Critical Moisture Content of A Given Material & Find Out Its Equation For Constant And Falling Rate Period.
6	Study of rotary dryer.
7	Study of forced draft cooling tower.
8	To preform differential distillation experiment and verify the Rayleigh equation.
9	To study vapor liquid equilibrium using simple distillation.
10	To study the steam distillation process using turpentine oil as a feed stock.
11	To study the effect of phase ratio on extraction of acetic acid (dispersed phase) by ethyl acetate (continuous phase).
12	To find out the number of stages required for extraction of acetic acid (dispersed phase) by ethyl acetate (continuous phase).

COURSE OUTCOMES

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

CO1 : Define the distillation, extraction, crystallization, drying, humidification, and dehumidification.
CO2 : Explain the extent of drying and cooling.
CO3 : Apply principles related to distillation, extraction, crystallization, drying, humidification, and dehumidification.
CO4 : Distinguish the effectiveness of distillation and extract.
CO5 : Determine the characteristics of cooling tower, equilibrium moisture content.
CO6 : Estimate the design parameters for distillation, crystallization, extraction, drying, humidification, and dehumidification.

TEXT/REFERENCE BOOKS

1. Mass Transfer Laboratory Manual
2. R.E. Treybal, Mass Transfer Operations, 3rd edition, International Student Edition, McGraw Hill Education
3. W. L. McCabe, J. Smith and P. Harriott - Unit operations of Chemical Engineering, 7th edition, McGraw-Hill international edition, 2005
4. B. K. Dutta, Principle of Mass Transfer and Separation Processes, Prentice Hall India Learning Private Limited, 2006
5. K. V. Narayanan, Mass Transfer: Theory and Applications, CBS Publishers, 2005
6. P. C. Wankat, Separations in Chemical Engineering: Equilibrium Staged Separations, Prentice Hall, NJ, US, 1988.

					Chemical Reaction Engineering 2					
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 accustom with the concepts of non-ideality in the reactor systems and studying RTD.
2. To provide details on modelling the non-ideality using zero and one parameter models
3. To give a wholesome picture on catalysis, catalytic reactions, and catalytic reactors
4. To give detail insight on external and internal mass transfer effects in catalytic reactions

UNIT 1 CATALYSIS AND CATALYTIC REACTORS **12 h**

Basics of catalysis, catalytic reactions, steps in a catalytic reaction, synthesizing a rate law, mechanism and rate-limiting step, design of reactors for gas-solid reactions, heterogeneous data analysis for reactor design, catalyst deactivation, multiphase reactors, catalytic reactors for deactivating catalysts (temperature time trajectories, circulating fluidized bed reactor, straight through transport reactor).

UNIT 2 EXTERNAL DIFFUSION EFFECTS **8 h**

External diffusion effects on heterogeneous reactions – mass transfer fundamentals, binary diffusion, external resistance to mass transfer, correlations for the mass transfer coefficient, the shrinking core model

UNIT 3 INTERNAL DIFFUSION EFFECTS **10 h**

Internal diffusion effects on heterogeneous reactions, diffusion, and reaction in catalysts, Thiele modulus, Weiz-Prater criterion, Mear's criterion, internal effectiveness, overall effectiveness, falsified kinetics, estimation of mass transfer and reaction limited regimes, Hatta number, multiphase reactors with diffusion and reaction (fluidized bed reactor, slurry reactor and trickle bed reactor)

UNIT 4 NON-IDEALITY AND RTD MEASURMENTS **12 h**

Basics of non-ideality, distribution of residence times for chemical reactors – general characteristics, RTD measurement, reactor modelling with RTD, models for non-ideal reactors: zero-parameter models and one parameter models, research studies on modelling of real reactors

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Select proper reaction mechanism and design the catalytic reactor by rate data analysis
- **CO2** : Compare the reactor performance with or w/o internal of external mass transfer limitations
- **CO3** : Appraise the performance of different reactors in multi-phase systems
- **CO4** : Design, Develop and/or Modify reactor systems for specific purpose of real-life problems
- **CO5** : Relate to the basics of non-ideal reactors and characteristics of residence time distributions
- **CO6** : Interpret the RTD profiles and experimental data to model the non-ideal reactors

TEXT/REFERENCE BOOKS

1. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd edition, New Delhi-Prentice Hall, 2001.
2. O. Levenspiel, Chemical Reaction Engineering, Willey Eastern, 3rd edition, 2000.
3. J. M. Smith, Chemical Engineering Kinetics, 3rd edition, McGraw- Hill, 1988.
4. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 1998.
5. LK Doraiswamy, MM Sharma, Heterogeneous Reactions, Vol I & II, John Wiley and Sons.

					Chemical Reaction Engineering 2 Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Understand the non-ideality of different reactors by performing RTD studies
2. Study the homogeneous reactions with and without catalysts to observe the change in the reaction performance.
3. Study the effect of mass transfer with and without reaction
4. Understand the modelling aspects using zero and one parameter model

SR.	LIST OF EXPERIMENTS
1	Residence time distribution studies in CSTR
2	Residence time distribution studies in PFR
3	Residence time distribution studies in PBR
4	To study non-catalytic homogeneous second order liquid phase reaction in packed bed reactor
5	To study the kinetics of dissolution of benzoic acid in water
6	To study the catalytic decomposition of hydrogen peroxide in an adiabatic reactor
7	Investigation of kinetics in a basket reactor
8	Investigation of kinetics for dehydration of acetate in a recycle reactor
9	Predict the conversion using segregation model for different reactors
10	Predict the conversion using maximum mixedness model for different reactors
11	Predict the conversion using tank in series model for different reactors

COURSE OUTCOMES

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

CO1 : Relate to the basics of non ideality in reactors and application of the same in practical
CO2 : Interpret the RTD data; evaluate different parameters and interpretations for different reactors
CO3 : Utilize the catalyst for the reaction and identify the catalytic effect on the performance of reaction
CO4 : Examine the effect of presence/absence of mass transfer limitations on the reaction
CO5 : Choose to model the RTD of a given reactor system and estimate the performance
CO6 : Develop an ability to work in group, learn report making, and improve soft skills in representing the findings

TEXT/REFERENCE BOOKS

1. Chemical Reaction Engineering Laboratory Manual
2. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd edition, New Delhi-Prentice Hall, 2001
3. O. Levenspiel, Chemical Reaction Engineering, Willey Eastern, 3rd edition, 2000
4. J. M. Smith, Chemical Engineering Kinetics, 3rd edition, McGraw- Hill, 1988
5. L. D. Schmidt, The Engineering of Chemical Reactions, Oxford University Press, 1998

UG Curriculum (2024 onwards)

Semester 7

Semester	Category Code	Course Code	Course Name	Theory	Tutorial	Practical	Hrs	Credits
Semester 7	Pro		Summer Internship	0	0	0	0	2
	OE		Open Elective 4 (Inter-department, FoET)	3	0	0	3	3
	PE		Program Elective 3	3	0	0	3	3
			Polymer Science & Technology					
			Energy Conversion Device Engineering					
			Pharmaceuticals Technology					
	PE		Program Elective 5	3	0	0	3	3
			Process Plant Safety, Health, and Hygiene					
			Project Management					
			Plant Design & Process Economics					
	PC		Process Modelling and Optimization	3	0	0	3	3
	PC Lab		Process Modelling and Optimization Lab	0	0	2	2	1
	PC		Computer Aided Process Design	3	0	0	3	3
	PC Lab		Computer Aided Process Design Lab	0	0	2	2	1
	PC		Transport Phenomenon	3	1	0	4	4
	Pro		Seminar	0	0	0	0	0
				18	**0**	**6**	**24**	**21**

					Polymer Science & 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 prepare students with basic knowledge of polymer science & technology that will help them to develop new materials.
2. To impart the critical knowledge about various complexities in polymerization reaction engineering
3. To teach the students various characterization techniques for identification, MW calculation, etc.
4. To prepare students for mastering few bulk polymers process technologies

UNIT I INTRODUCTION TO POLYMER SCIENCE **10 h**

Classification and nomenclature of polymers, Monomer and functionality, Polymerization and degree of polymerization, Types of molecular weights and its distribution, Molecular Weights determination, Factors affecting molecular weight and molecular weight distribution, Chain-transfer reactions, Thermal and Mechanical properties of polymers, concept of stereochemistry of polymers.

UNIT II CHEMISTRY OF POLYMERIZATION **10 h**

Classification of polymerization mechanism, Stepwise polymerization, Kinetics and statistics of linear stepwise polymerization, Radical chain (Addition) polymerization – reaction mechanisms and associated kinetics, Copolymerization – reaction mechanisms and kinetics, Techniques of Polymerization: Bulk, Solution, Suspension & Emulsion.

UNIT III INDUSTRIAL POLYMER PRODUCTION AND SPECIALITY POLYMERS **12 h**

Production of bulk polymers: polyethylene, polypropylene, polyvinylchloride, styrene butadiene rubber, polyester and Polyamide (Nylon); Specialty polymers: Conducting polymers, Block copolymers, Polymer composites, polymer blends, polyurethanes, Silicones and other inorganic polymers: Rubbers, epichlorohydrin, polysulphides, acrylic rubbers and silane-containing polymers.

UNIT IV POLYMER PROCESSING TECHNIQUES & ENTREPRENEURSHIP IN POLYMERS **10 h.**

Polymer Processing: Injection Moulding, Extrusion, Thermoforming, calendaring, Compression moulding, Blow moulding, Spinning of fibres, Vulcanization and reinforcement of rubbers, Importance of Tg in processing, Dependence of small and medium scale industries on polymer processing, Entrepreneurship opportunities available in polymer processing

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : list & recall the basic concepts of polymer Science.
- **CO2** : classify and compare different polymerization reactions and interpret polymerization methods judiciously
- **CO3** : Identify and develop the knowledge of different processes of bulk polymers production.
- **CO4** : discover the importance of speciality polymers for different industrial and day-to-day applications.
- **CO5** : assess and compare the different techniques of polymer processing in industries.
- **CO6** : identify the various entrepreneurship opportunities available in polymer processing.

TEXT/REFERENCE BOOKS

1. F.W. Billmeyer, Textbook of Polymer Science, John Wiley, 2008
2. V.R. Gowarikar, Polymer Science, New Age International, 2016
3. M.P. Stevens, Polymer Chemistry, Oxford University Press, 1999
4. G. Odian, Principle of Polymerization, Wiley, 2004

					Energy Conversion Device 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. 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 I INTRODUCTION AND BASIC PRINCIPLES **12 h**

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 II BATTERY FUNDAMENTALS **10 h**

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 III FUEL-CELL FUNDAMENTALS **10 h**

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 IV PHOTOELECTROCHEMICAL CELLS AND ELECTROCHEMICAL DOUBLE-LAYER CAPACITORS **10 h**

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

Maximum 42 h

COURSE OUTCOMES

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

					Pharmaceuticals 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. Acquire the knowledge of basic pharmaceutical technology and characteristics of pharmaceutical industries.
2. Gain an understanding of Sterilization applications and Dosage farms.
3. Understand and apply methods for Manufacturing and packaging of pharmaceutical products.
4. Understanding advanced pharmaceutical manufacturing and use of AI in Pharmaceutical Industry

UNIT I BASICS OF PHARMACEUTICAL TECHNOLOGY **8 h**

Characteristics of Pharmaceutical industries, Product Standards: IP, BP, USP, Methods of production, AI in pharmaceutical production, Chemical synthesis, Isolation from plants, isolation from animals, Fermentation, API and Formulation, Nano medicine, Drug design for targeted drug delivery, Diffusion modeling of drug delivery and coding to solve.

UNIT II STERILIZATION AND CHARACTERIZATION **10 h**

Sterility and requirement of sterility, Concept of bacterial and viral infection, Natural growth of bacteria, fundamental concept of bacteria culture, Concept of sterilization. Methods of Sterilization with, applications, Heat sterilization, Steam sterilization, Dry heat sterilization, Radiation sterilization Gas sterilization, Filtration sterilization. Sterile facilities. Use of UV-VIS, FTIR, Raman spectroscopy, and HPLC in Pharmaceutical industry.

UNIT III CLEAN FACILITIES, CLEAN ROOM, AND DOSAGE FORMS **12 h**

Design parameters for clean facilities: Air change rate, Pressurization, Temperature control, Humidity control. Architectural design issues. Material of construction for wall, doors, ceilings, floors, Clean construction. HEPA filters, Production of HEPA filters by Electrospinning. Air Quality Monitoring, Indoor Air Quality (IAQ), HVAC unit, clean room facility, Role of Artificial Intelligence in air quality monitoring, and Solid dosage forms: Tablets, Coated tablets, Gelatine capsules, Chewable tablets. Excipients in solid dosage forms. Semi-Solid dosages: Ointments and creams, Bases for ointments and creams, Types of Gels, Commercial Gelling agents

UNIT IV MANUFACTURING AND PACKAGING AND USE OF AI **10 h**

Manufacturing, tablets and capsules, Advanced Manufacturing in Micro-reactors, Usage of AI in advanced drug manufacturing units, Packaging and storage of ointments and creams, Critical aspects of liquid manufacturing: particle size of raw materials, parameters of compounding, uniformity, stability problems. Packaging materials: General considerations, Glass, Plastic and metal. Quality control of packaging materials

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Understand key concepts of pharmaceutical technology
CO2 : Identify appropriate methods in medicine production.
CO3 : Apply various methods of sterilization.
CO4 : Air Filters, Clean Room, HVAC unit, AI based IAQ
CO5 : Produce different dosage forms, packaging materials for pharmaceutical products
CO6 : AI in pharmaceutical Industries

TEXT/REFERENCE BOOKS

1. Hickey, Anthony J, David Ganderton, Pharmaceutical Process Engineering, Marcel Dekker Inc., 2001.
2. Gad, Shayne Cox, Pharmaceutical Manufacturing handbook. John Wiley and Sons, 2008.
3. Sharp, John, Good pharmaceutical Manufacturing practice, CRC press, 2005.
4. Latest Research articles in similar field and materials from Github

					Process Plant Safety, Health, and Hygiene					
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 engineering ethics, accident & loss statistics, and hazard identification.
2. To have knowledge hazard analysis, toxicology, personal protective equipment, and risk assessment.
3. To learn about fire and explosion hazards, their prevention and risk analysis.
4. To gain the knowledge of identification, evaluation, and control of industrial hygiene.

UNIT I INTRODUCTION **12 h**

Engineering ethics, Accident and loss statistics, Nature of accident process, Inherent safety in process, Indore air quality management, personal safety aspects, PPE, Toxicology. National and International standards for health and safety, Acts and legislation (OSHA, ISO standards), REACH regulations. Hazard Identification: Hazard surveys, Hazard & operability study, Hazard analysis.

UNIT II FIRE AND EXPLOSION HAZARDS **10 h**

Fire triangle, Flammability characteristics of fluids, Limiting oxygen concentration, Flammability diagram, Explosions, DOW F&I Index, Prevention- Inerting, Ventilation, Sprinkler systems, Explosion proof instruments and equipments and control rooms, Miscellaneous concepts for preventing fire and explosions.

UNIT III INDUSTRIAL HYGIENE **10 h**

Government Regulations, Identification-Material safety data sheet, Evaluation, and control. Risk Assessment: Fault tree analysis (FTA), Event tree analysis (ETA), Review of probability theory, Quantitative Risk Analysis, LOPA concept.

UNIT IV MAJOR DISASTERS AND MISCELLANEOUS CONCEPT **10 h**

Case study on major disaster in chemical process industry, Introduction to relief and sizing of reliefs systems, location of flare system and knockout pots.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Define the engineering ethics, safety principles, toxicology, hazards and industrial hygiene.
CO2 : Classify protective measures to mitigate risk and implementation of safety, health, and industrial hygiene.
CO3 : Apply knowledge in risk management, accident and loss statistics.
CO4 : Examine industrial hygiene, risk assessment and probability theory, Quantitative Risk, LOPA concept.
CO5 : Assess typical sources of risk in a process plant by hazard identification and case studies.
CO6 : Estimate fire & explosion hazard identification, evaluation and control.

TEXT/REFERENCE BOOKS

1. Daniel A. Crowl and Joseph F. Louvar, Chemical Process Safety: Fundamentals with Applications, Prentice Hall, 1990.
2. Nicholas P Cheremisinoff, Practical Guide to Industrial Safety, Marcel Dekker, 2001.
3. Laird Wilson, Doug McCutcheon, Marilyn Buchanan, Industrial Safety and Risk Management, University of Alberta Press, 2003.

					Project Management					
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. Acquire and fine-tune the skills and techniques for the 4 phases in the life cycle of a typical project.
2. Gain an understanding of essential principles associated with effective project management.
3. Understand and apply methods for solving common difficulties associated with project management.
4. Gain knowledge of AI/ML based project management concept.

UNIT I INTRODUCTION TO PROJECT MANAGEMENT **10 h**

Definition of project, Project Management Vs. General Management, The life cycle of projects, Confronting Uncertainty, Project portfolio process, An approach to Project Formulation. The PM's Roles, The PM's responsibility to the project, Selection of a Project Manager. Fitting projects into the parent organization, The project team

UNIT II PLANNING AND BUDGETING THE PROJECT **10 h**

The contents of a project plan, The planning process- detailed overview, The work breakdown structure and other aids, Multidisciplinary Teams-Balancing Pleasure and Pain. Methods of budgeting, Cost estimating, Improving Cost Estimates, Budget Uncertainty and risk management

UNIT III SCHEDULING AND ALLOCATING THE RESOURCES TO THE PROJECT **10 h**

PERT and CPM Networks, Project uncertainty and risk management, Simulation, Machine Learning based risk assessment and project management, The Gantt chart, Extensions to PERT/CPM. Expediting a Project, Resource Loading, Resource Levelling, Allocating Scarce resources to projects.

UNIT IV MONITORING AND CONTROLLING THE PROJECT **12 h**

Project Monitoring and Control: Project Work Measurement, Performance Measurement, Earned Value Management, Estimate Revision, control of overrunning of project from time and cost. Project Closure and Review: Performance Evaluation – Scope, Time and Cost, Performance of Teams, Lessons Learnt, Project Closure Report, AI based cost analysis-performance monitoring, and preparation of closure report.

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Understand key concepts of project management and project lifecycle
- **CO2** : Ability to analyse the principles of management, planning, specifications, and requirements.
- **CO3** : Understanding the processes involved in the effective planning and subsequent management of projects.
- **CO4** : Construct the key stages of managing projects, scheduling of tasks, risk analysis, the role of the project manager through various techniques such as CPM, PERT, Gantts chart, etc.
- **CO5** : Develop increased awareness of available resources to further develop project management skills.
- **CO6** : Elaborate new knowledge to their own projects and set realistic goals for moving forwards, and Role of AI in project Management

TEXT/REFERENCE BOOKS

1. Maylor, Harvey, Project Management, 3rd edition, Pearson, 2003
2. Pinto, Jeffrey K., Project Management: Achieving Competitive Advantage and MS Project, 1st edition, Pearson, 2009
3. Sitangshu Khatua, Project Management and Appraisal, Oxford
4. Online resources from Github and similar

					Plant Design & Process 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. To study the basics of process flow diagram formulation
2. To know the detailed-estimate design procedure
3. To understand the effect of design parameters on the process design, and methodology to estimate these design parameters
4. To understand the concepts of economic analysis of the process and the necessity of optimized design.

UNIT I INTRODUCTION TO PLANT DESIGN AND PROCESS ECONOMICS **10 h**

Basic concepts: General design considerations, Process design development, Layout of plant items, Flow sheets and PI diagrams, Economic aspects and Optimum design, Practical considerations in design and engineering ethics, Degrees of freedom analysis in interconnected systems, Direct and Indirect costs

UNIT II DESIGN CONSIDERATION AND PROCESS DESIGN DEVELOPMENT **10 h**

Synthesis of flow sheet: Propositional logic and semantic equations, Deduction theorem, Algorithmic flow sheet generation using P-graph theory, Sequencing of operating units, Feasibility and optimization of flow sheet using various algorithms viz, Solution Structure Generation (SSG), Maximal Structure Generation (MSG), Simplex, Branch-and-bound etc.

UNIT III ANALYSIS OF COST ESTIMATION FOR PROCESS EQUIPMENT **12 h**

Factors affecting Investment and production costs, Estimation of capital investment and total product costs, Interest, Time value of money, Break-even analysis, Taxes and Fixed charges, Salvage value, Methods of calculating depreciation, Profitability, Alternative investments and replacements, Cost and Asset Accounting; Cost Estimation; Interest and Investment Costs; Taxes and Insurance; Depreciation; Profitability, Alternative Investments and Replacement; Illustrative Case Study in Process Equipment Design and Costing of Equipment in each of the following categories: Material Transfer, Handling and Treatment Equipment Heat Transfer Equipment: Shell and tube heat exchangers (Kern and Bell-Delaware design methods), Plate heat exchangers, Evaporators, Mass Transfer Equipment: Absorption/Stripping columns (packed/tray), Multicomponent distillation column (Fenske-Underwood-Gilliland correlations), Reactors: choice of reactors, non-isothermal reactors, reactor configuration, inter stage heating/cooling, multi-tubular reactors, catalyst deactivation.

UNIT IV OPTIMIZATION AND DESIGN STRATEGY **10 h**

Optimum production rates in plant operation, Optimum batch cycle time applied to evaporator and filter press, Economic pipe diameter, Optimum insulation thickness, Optimum cooling water flow rate and optimum distillation reflux ratio.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Understand the basic concepts of process flow sheet formulation
CO2 : Evaluate the detailed process design
CO3 : Know the economic analysis of the overall process
CO4 : Correlate the design with equipment cost
CO5 : Find the best optimum condition used in the design
CO6 : Analyse the existing process plant performance

TEXT/REFERENCE BOOKS

1. Peters, Timmerhause and West, Plant Design and Economics for Chemical Engineers, 5th edition, McGraw Hill, 2011.
2. Smith, Chemical Process Design and Integration, 2nd edition, Wiley, 2016.
3. Towler, G., and Sinnott, R., Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design, Butterworth-Heinemann, 2021.

					Process Modelling and Optimization					
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 make the students understand the various essential features of physical and mathematical modelling and their applications of chemical engineering processes.
2. To develop the mathematical models and solutions for these models using analytical and numerical solutions. The students will also learn to use the commercial process simulators.
3. To provide an overview of state-of-the-art optimization algorithms, the theoretical principles that support them, and to provide students with the modelling skills necessary to describe and formulate optimization problems.
4. To develop the technical skills for solving several types of practically relevant optimization problems arising in process systems engineering.

UNIT I OVERVIEW OF MODELING OF CHEMICAL PROCESSES **10 h**

Introduction to mathematical modelling: Uses of Mathematical models, Scope of coverage, Principles of formulation. Fundamental laws: continuity equations, energy equations, equations of motion, transport equations, equations of state, equilibrium, chemical kinetics

UNIT II MATHEMATICAL MODEL DEVELOPMENT **10 h**

Examples of mathematical models of chemical engineering systems: Introduction, series of Isothermal constant-holdup CSTRs, CSTRs with variable holdups, two heated tanks, gas phase, pressurised CSTRs, Non isothermal CSTR, single component vaporizer, multi-component flash drum, batch reactor, reactor with mass transfer.

UNIT III INTRODUCTION OF OPTIMIZATION AND TRADITIONAL OPTIMIZATION TECHNIQUES **14 h**

Single variable optimization algorithms: Optimal problem formulation, Optimization algorithms, Optimality criteria, Bracketing methods, region elimination methods, point-estimation method, Gradient based methods, root finding using optimizing technique. Multi variable optimization algorithms, Unidirectional search, direct search methods Linearized search techniques, Generalized reduced gradient method, Simplex method.

UNIT IV NON-TRADITIONAL OPTIMIZATION TECHNIQUES **8 h**

Specialized algorithms: Integer programming. Non-traditional optimization algorithms: Genetic algorithms, simulated annealing, Optimization using Artificial Neural Network

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Relate the important physical phenomena from the problem statement, various types of models such as empirical models, hybrid models etc.
- **CO2** : Translate chemical process systems into mass balance, energy balance and momentum balance formulations
- **CO3** : Develop model equations for the given system, demonstrate the model solving ability for various processes/unit operations, develop various models for various systems such as reactor, distillation column, heat exchangers and analyse their behaviour.
- **CO4** : Be able to theoretically examine different types of optimization problems.
- **CO5** : Assess the utilization of different optimization techniques.
- **CO6** : Ability to solve various multivariable optimization problems.

TEXT/REFERENCE BOOKS

1. T. F. Edgar and D. M. Himmelblau, Optimization of Chemical Processes, 2nd edition, McGraw Hill, 2001
2. Luyben, Process Modelling, Simulation and Control for Chemical Engineers, Optimization of Chemical Processes, 2nd edition, McGraw-Hill, 2001
3. B. Wayne Bequette, Process Dynamics Modelling, Analysis and Simulation, Prentice Hall International Series
4. Deb Kalyanmoy, Optimization for Engineering Design Algorithms and Examples, 2nd edition.
5. B.V. Babu, Process Plant Simulation, Oxford Higher Education, 2007
6. J. K. Sharma, Operations research Theory and Applications, 5th edition, MacMillan.

UG Curriculum (2024 onwards)

					Process Modelling and Optimization Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Acquire a foundational understanding of computational tools for computer-aided calculations and the utilization of specialized toolboxes.
2. Develop skills in coding and model development for regression analysis, optimization problems, and solving Ordinary Differential Equations (ODEs) using computational software.
3. Learn the application of computational techniques for analyzing and solving complex engineering problems, including both linear and non-linear scenarios.
4. Enhance problem-solving capabilities through practical exercises in coding, model development, and the application of optimization algorithms in engineering contexts.

SR.	LIST OF EXPERIMENTS
1	Reacquaint with GUI of computational software and basic computation (open source and proprietary)
2	First and second order numerical differentiation of functions using forward, backward and central FDE
3	Curve fitting (using coding as well as toolboxes) and non-linear and polynomial regression analysis of chemical engineering data for model development
4	Develop and solve chemical engineering models (first order ODEs) using in-built functions in computational tools.
5	Develop and solve chemical engineering models (first order ODEs) using ODE solving algorithms like Runge Kutta - 1, 2, 4 using computational tools.
6	Develop and solve chemical engineering models (higher order ODEs) using in-built functions in computational tools.
7	Optimization algorithms coding in computational tools (Open methods like Secant, Newton Raphson)
8	Optimization algorithms coding in computational tools (Bracketed methods like Bisection, Regula-Falsi)
9	Solving chemical engineering problems in optimization: Linear and Mixed Integer Programming
10	Practicing optimization problems using sophisticated algorithms: Box's Evolutionary algorithm
11	Practicing optimization problems using sophisticated algorithms: Simplex Search Method
12	Basic understanding and application of ANN toolbox

COURSE OUTCOMES

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

CO1 : Understand GUIs of computational software for chemical engineering applications.
CO2 : Apply numerical differentiation and curve fitting to chemical engineering data analysis.
CO3 : Analyse and solve first-order ODE models using computational tools.
CO4 : Solve higher-order ODEs in chemical engineering using computational methods.
CO5 : Design optimization algorithms for chemical engineering problems.
CO6 : Apply specialized toolboxes in MATLAB for chemical engineering solutions.

TEXT/REFERENCE BOOKS

1. Process Modelling and Optimization Lab Manual
2. Steven C. Chapra and Raymond P. Canale, Numerical Methods for Engineers, McGraw-Hill Education.
3. Victor J. Law, Numerical Methods for Chemical Engineers Using Excel, VBA, and MATLAB, CRC Press.
4. Abdelwahab Kharab and Ronald B. Guenther, An Introduction to Numerical Methods: A MATLAB Approach, CRC Press.
5. Amos Gilat, Numerical Methods for Engineers and Scientists: An Introduction with Applications Using MATLAB, Wiley.
6. Michael R. King and Nipa A. Mody, Numerical and Statistical Methods for Bioengineering: Applications in MATLAB, Cambridge University Press.

					Computer Aided Process Design					
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 the scope of process and plant design using software tools: Create, select, and apply appropriate modern software tools 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 applications and solve chemical process flow sheeting problems more quickly, efficiently, and successfully using computer-aided tools.
4. Learn concepts of Energy integration and solve heat exchanger network problems in Aspen energy analyser.

UNIT I BASICS OF COMPUTER AIDED PROCESS DESIGN **12 h**

Integrated process plant design with computer-aided tools, PFD, P&ID, pre-FEED, FEED stages. Process simulators: components and architecture, blocks and streams library, CAPD problem formulation and solvers, model equations and Degrees of freedom, Design, rating, specification and optimization formulation; sequential modular and Equation oriented approach, tearing of stream, scopes of Aspen Plus/hysis simulator, flowsheeting problem solving using design specifications, sensitivity analysis

UNIT II COMPUTERISED PHYSICAL AND THERMODYNAMICS PROPERTY, METHODS AND MODELS **10 h**

Computerized physical and thermodynamic properties, methods and models, ideal and non-ideal model selection criteria, Thermodynamics databanks; NIST data bank, estimation of activity coefficient and EOS model parameters using data regression system, Case studies and flow sheeting problem solving of mass and energy balance, phase equilibrium, chemical equilibrium and reactor design using commercial software (Aspen Plus).

UNIT III COMPUTER SIMULATION OF MASS AND HEAT TRANSFER EQUIPMENTS **10 h**

Design and simulation of distillation and absorption column, equilibrium, and rate-based approach; design, rating and simulation of heat exchangers, Petroleum fractionation columns, Various unit models available in Aspen Plus library and their usage.

UNIT IV PROCESS INTEGRATION AND HEAT EXCHANGER NETWORKS **10 h**

Introduction to process Intensification Process Integration, Heat Exchanger networks (HEN), cold, hot composite and Utility curves, pinch point analysis, Solving HEN problems using Aspen Plus energy analyser

Maximum 42 h

COURSE OUTCOMES

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

- **CO1** : Understand/select/describe the fundamentals and computer tools for chemical industrial process simulation applications
- **CO2** : Understand/choose/apply the unit operation/process blocks and material/energy streams from a simulator library to make a process flow sheet
- **CO3** : Identify/Choose/Justify the components of physical and thermodynamic property methods and models and their usage in software aspects of rapid solution
- **CO4** : Determine flow sheeting solution/design calculations by using design specification and sensitivity analysis approach in Aspen Plus software
- **CO5** : Solve process design and simulation calculations of various unit operations/processes using Aspen software
- **CO6** : Outline energy integration and construct Heat exchanger network using the composite curve approach.

TEXT/REFERENCE BOOKS

1. Juma Haydary, Chemical Process Design and Simulation, John Wiley &Sons, Inc.
2. Bruce A. Finlayson, Introduction to Chemical Engineering Computing, Wiley Interscience.
3. Amiya K. Jena., Process Simulation and Control using Aspen, PHI Learning Pvt Ltd.
4. Kamal I.M. Al-Malah, ASPEN PLUS® Chemical Engineering Applications, John Wiley & Sons, Inc.,

					Computer Aided Process Design Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	h/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	50	50	100

COURSE OBJECTIVES

1. Understand the software to Create, select, and apply appropriate modelling and simulation of complex chemical engineering processes with an understanding of the limitations
2. identify and apply the components of physical/thermodynamic property methods and models and Learn software aspects of rapid solution.
3. Learn applications and solve chemical process flow sheeting problems more quickly, efficiently and successfully using computer-aided tools (Aspen Plus)
4. Learn concepts of Energy integration and solve heat exchanger network problems in Aspen Plus.

SR.	LIST OF EXPERIMENTS
1	To Construct a process flow diagram and simulation sheet with process blocks and streams
2	To estimate Physical properties such as Critical properties, ΔH, ΔG etc of organic compounds
3	Thermodynamic property estimation and analysis, T-xy, P-xy and xy diagrams of binary mixture
4	Regression of Vapour-liquid equilibrium data, Flash separation, dew point, bubble point,
5	Gibbs reactor, equilibrium reactor, yield reactors
6	Kinetic reactors Batch, CSTR, PFR
7	heat exchangers, design, rating, calculation with TEMA specification
8	Thermal analysis, simulation of heat exchanger
9	Design and Simulation of distillation and absorption column,
10	Modelling of Azeotropic distillation using pressure swing with Redfrac
11	case study: ammonia production process) Open loop process
12	Costing and economic analysis; (case study: ammonia production process) Closed loop process
13	Solving Heat exchanger network using Aspen energy analyser

COURSE OUTCOMES

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

CO1 : Understand and estimate, the physical/ thermodynamic properties of organic compounds.
CO2 : Develop flow sheet for mass and energy balance calculation using Aspen plus
CO3 : Construct thermodynamic phase diagrams (t-xy, p-xy, xy) using activity coefficient and Equation of State models. Analyse and compare them.
CO4 : Determine design solution by using design specification and sensitivity analysis approach
CO5 : Verify and compare process design and simulation calculations of various unit operations in Aspen Plus
CO6 : Demonstrate Heat exchanger network design/composite curves using Aspen energy analyser

TEXT/REFERENCE BOOKS

1. Computer Aided Process Design Lab Manual
2. Juma Haydary, Chemical Process Design and Simulation, John Wiley &Sons, Inc.
3. Bruce A. Finlayson, Introduction to Chemical Engineering Computing, Wiley Interscience.
4. Amiya K. Jena., Process Simulation and Control using Aspen, PHI Learning Pvt Ltd.
5. Kamal I.M. Al-Malah, ASPEN PLUS® Chemical Engineering Applications, John Wiley & Sons, Inc.,

					Transport Phenomena					
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. Identify the transport processes involved in some simple situations.
2. Understanding the equations of change for mass, momentum and energy and the requisite boundary conditions for each equation of change.
3. Solve the simplified problem analytically with the requisite mathematical framework and assess the physical significance of the solution obtained.
4. Examine the range of applicability and the limitations of the solution.

UNIT I FUNDAMENTALS OF TRANSPORT PROCESSES **10 h**

Vector and Tensor Analysis, Curvilinear Coordinates, Continuum Approximation, Eulerian and Lagrangian approach, Reynolds transport theorem, General forms of Conservation Equations, Conservation of Mass, Momentum and Energy, Constitutive Equation, Viscosity and mechanism of momentum transport, Thermal conductivity and mechanism of energy transport, Diffusivity and mechanism of mass transport.

UNIT II SHELL BALANCE METHOD **10 h**

Application of shell momentum balance to Cartesian, cylindrical and spherical coordinate systems, Derivation of momentum transport equation, heat transport equation and mass transport equation using steady state shell balance in different coordinate systems, Different types of boundary conditions, Solving simple transport problems by using shell balances.

UNIT III EQUATIONS OF CHANGE **12 h**

Application of frame independent form of Momentum, Energy and Mass conservation equations, Dimensional analysis and different flow regimes, Obtaining analytical solutions of transport problems by using Navier-Stokes, Cauchy Momentum equation, Energy and Mass transport equations in different coordinate systems. Coupling between various equations and brief introduction to CFD.

UNIT IV MORE THAN ONE INDEPENDENT VARIABLE SYSTEMS **10 h**

Solving transport problems with more than one independent variable systems: Velocity distribution, temperature distribution, concentration distribution, CFD based transport modelling (one demo example), Introduction to Turbulent Flow.

Maximum 42 h

COURSE OUTCOMES

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

CO1 : Define the momentum, energy and mass fluxes and their individual components.
CO2 : Compare various coordinate systems and accordingly identify the direction of forces and fluxes on given type of shell.
CO3 : Application of shell balance methods to find out equations of momentum, energy, and mass transport in terms of flux quantities.
CO4 : Simplifying various transport problems by using various equations of change.
CO5 : Choose boundary conditions and mathematical techniques to solve equations of change.
CO6 : Compose and formulate moderately complex transport problems from scratch.

TEXT/REFERENCE BOOKS

1. R. B. Bird, W. E Stewart, and E. N. Lightfoot, Transport Phenomena, Edition-I John Wiley, 1960.
2. L. Garry Leal, Advanced Transport Phenomena, Cambridge University Press, 2007.
3. Deen, W.M., Analysis of transport phenomena, Oxford University Press, 1998.