



# **Second Year Curriculum**

**Admission Year 2026-27**

**Bachelor of Technology (Lateral)**

**Chemical Engineering**

**Faculty of Engineering & Technology**

**Parul University**

**Vadodara, Gujarat, India**

### Semester 3

(1)

- a. **Course Name:** Particle and Fluid Particle Processing
- b. **Course Code:** 03010303PC01
- c. **Prerequisite:** Basic knowledge of mathematics, fluid mechanics, thermodynamics, and material properties is required to understand particle and fluid particle processing.
- d. **Rationale:** This course helps students understand the behaviour, motion, and processing of particles in fluids, which is essential for designing and analyzing engineering systems in chemical and related industries.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	To enable the students about the fundamental concepts of solid particle characteristics.
<b>CLOBJ 2</b>	To equip the students to solve practical problems related to fluidized bed operations, including minimum fluidization velocity and pressure drop.
<b>CLOBJ 3</b>	To make the students capable to classify various separation methods for solid-solid, solid-gas, and solid-liquid mixtures.
<b>CLOBJ 4</b>	To make the students understand how to determine size reduction techniques, crushing equipment.
<b>CLOBJ 5</b>	To enable the students to identify different types of mixing, agitation and conveying of solids and estimating the power requirement

f. **Course Learning Outcomes:**

<b>CLO 1</b>	Explain the fundamental concepts of solid particle characteristics.
<b>CLO 2</b>	Solve practical problems related to fluidized bed operations, including minimum fluidization velocity and pressure drop.
<b>CLO 3</b>	Classify various separation methods for solid-solid, solid-gas, and solid-liquid mixtures.
<b>CLO 4</b>	Determine size reduction techniques, crushing equipment.
<b>CLO 5</b>	Identify different types of mixing, agitation and conveying of solids and estimating the power requirement

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	-	-	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

## h. Course Content:

Sr.	Topics	Weightage (%)	Teaching (hr)
1	<b>Solid particle characteristics:</b> Introduction to unit operations and their role in Chemical Engineering industries. Types of mechanical operations. Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area, Measurement of surface area. Differential and cumulative screen analysis, different mean diameters for a mixture of particles.	25	11
2	<b>Fluidization:</b> Fluidized bed, minimum fluidization velocity, pressure drop. Types of fluidizations: Particulate fluidization, Bubbling fluidization, Classical models of fluidization, Circulating fluidized beds, Applications of fluidization.	15	7
3	<b>Mechanical Separation:</b> Classification of separation methods for mixtures of solid- solid, solid-gas and solid-liquid. Screening, Magnetic Separation, Electrostatic separation. Gravity settling, free settling, hindered settling, sedimentation, floatation. Continuous thickeners Phase separation: centrifugal separation, electrostatic precipitators. Gas-Solid separation: gravity settling, cyclone separators, Scrubbers. Theory of filtration, Principles of cake filtration, Batch and continuous filters, Flow through filter cake and filter media, Filter aids, compressible and incompressible filter cakes, Filtration equipment - selection, classification and working operations.	25	11
4	<b>Size reduction and enlargement</b> Principles of size reduction: Specific properties of solids for size reduction. Energy required for size reduction. Crushing efficiency, Laws of crushing, Classification of crushing equipment. Size enlargement: Scope and applications, size enlargement techniques, principle of granulation, nucleation, palletization, stabilization and flocculation.	15	7
5	<b>Handling of particulate solid</b> Conveying: Types of conveyors, Mechanical - belt, chain, screw conveyors, elevators, hydraulic & pneumatic conveyors. Mixing and agitation - Mixing of liquids (with or without solids), Mixing of powders, Selection of suitable mixers, Mixing equipment	20	9
Total		<b>100%</b>	<b>45</b>

## i. Text Book and Reference Book:

- Programming in ANSI C (Textbook) By E. Balaguruswamy | Tata McGraw-Hill.
- C Programming: Test Your Skills By Ashok Kamthane.
- Computer Fundamentals By P.K. Sinha and Priti Sinha | BPB Publications | 4th

Edition.

5. Star C Programming STAR Certification | C Certification Exam.
6. Programming with C By Byron Gottfried | Tata McGraw Hill Education.
7. C The Complete Reference By Herbert Schildt
8. Let Us C By Yeshavant Kanetkar | BPB Publications

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- a. **Course Name:** Particle and Fluid Particle Processing Lab
- b. **Course Code:** 03010303PC02
- c. **Prerequisite:** Basic knowledge of particle technology, fluid mechanics, measurement techniques, and laboratory safety is required for the Particle and Fluid Particle Processing Lab.
- d. **Rationale:** This course helps students understand the behaviour, motion, and processing of particles in fluids, which is essential for designing and analyzing engineering systems in chemical and related industries.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	To equip the student to determine particle size distribution data to understand material properties.
<b>CLOBJ 2</b>	To enable the students to verify the crushing laws by finding rate constants.
<b>CLOBJ 3</b>	To enable the students to determine specific cake resistance and filter medium resistance.
<b>CLOBJ 4</b>	To enhance the students to interpret separation efficiency, overall collection efficiency for batch settling data.
<b>CLOBJ 5</b>	To enable the students to estimate the energy requirement for grinding operations based on the size distribution data.

- f. **Course Learning Outcome:**

<b>CLO1</b>	Determine particle size distribution data to understand material properties.
<b>CLO2</b>	Verify the crushing laws by finding rate constants.
<b>CLO3</b>	Determining specific cake resistance and filter medium resistance.
<b>CLO4</b>	Interpret separation efficiency, overall collection efficiency for batch settling data.
<b>CLO5</b>	Estimate the energy requirement for grinding operations based on the size distribution data.

- g. **Teaching & Examination scheme**

Teaching Scheme				Examination Scheme				Total
L	T	P	C	Internal Marks		External Marks		
Hrs/Week	Hrs/Week	Hrs/Week		CE	P	T	P	
0	0	2	1	10	15	0	25	50

- h. **Course Content (List of Practicals)**

Sr. No.	Topics
1.	Using Sieve Analysis to determine a. Volume surface mean diameter b. Mass mean diameter c. Number of particles in the given sample of the mixture.
2.	To determine Nip Angle, Reduction ratio, Ribbon Factor, Rittinger's Constant, Bond's Constant, Kick's Constant, Work Index, Theoretical and Actual Capacity by using Jaw crusher.
3.	To find specific cake resistance and filter medium resistance by using sparkler filter press.
4.	To verify laws of crushing by finding rate constants for Rittinger's, Kick's and Bond's law by using Roll crusher.
5.	Obtain the batch settling data for the given sample by using batch sedimentation.
6.	To reduce the size of given material using ball mill and obtain the size distribution by sieving. Estimate the energy required for grinding operation.

7.	To Calculate 1) Minimum size of the particles separated. 2) Cut size of particles for calculation of Separation efficiency 3) Separation Efficiency 4) Overall Collection Efficiency by using plate and frame filter press.
8.	To determine the following values at constant (various) filtration pressures 1) flow rates through the filters 2) Specific Cake Resistance 2) Filter Medium Resistance 3) Rm Cake Compressibility.

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- a. **Course Name:** Fluid Mechanics
- b. **Course Code:** 03010303PC03
- c. **Prerequisite:** Basic Knowledge of Unit Operations, this course is to introduce the mechanics of fluids (fluid statics and fluid dynamics), relevant to Chemical Engineering operations
- d. **Rationale:** The course will introduce students to forces on fluids, hydrostatic forces on submerged bodies, Eulerian and Lagrangian descriptions of flow, flow visualization, integral analysis involving mass and momentum balances, Bernoulli equation, flow through pipes and ducts, flow measurement and instruments, flow transportation - pumps, blowers and compressors, conservation of mass, linear and angular momentum in differential form, Navier-Stokes equation, viscous flows, skin and form friction, lubrication approximation, potential flows and boundary layer theory.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	To enable the students to understand fundamental principles of fluid statics and its applications
<b>CLOBJ 2</b>	To enable the students to understand fluid dynamics, basic fluid flow equations to solve engineering problems.
<b>CLOBJ 3</b>	To equip the students to analyze flow behavior in pipes, fittings, and compressible flow systems.
<b>CLOBJ 4</b>	To enhance the students to evaluate and select suitable fluid machinery and transportation devices.
<b>CLOBJ 5</b>	To equip the students to perform flow measurement and dimensional analysis for engineering design.

f. **Course Learning Outcomes:**

<b>CLO 1</b>	Understand fundamental principles of fluid statics and its applications
<b>CLO 2</b>	Understand fluid dynamics, basic fluid flow equations to solve engineering problems.
<b>CLO 3</b>	Analyze flow behavior in pipes, fittings, and compressible flow systems.
<b>CLO 4</b>	Evaluate and select suitable fluid machinery and transportation devices.
<b>CLO 5</b>	Perform flow measurement and dimensional analysis for engineering design.

g. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr.	Topics	Weightage (%)	Teaching (hr)
1	<b>Fundamentals of Fluid Statics:</b> Properties of fluids, Pressure, hydrostatic equilibrium, Decanters, Newtonian & non-Newtonian fluids, pressure variation in a static fluid - application to manometer.	20	9
2	<b>Dynamics &amp; Basic Fluid Flow Equations:</b> Viscosity, Laminar vs turbulent flow, Reynolds number, stresses, eddy viscosity, Boundary layer theory, separation, wake formation Mass & average velocity, Potential flow, Streamlines & stream tubes, Macroscopic momentum balance, Continuity equation, Bernoulli's equation & corrections, Angular momentum equation	20	9
3	<b>Flow in Conduits &amp; Compressible/Non-Compressible Systems:</b> Laminar flow equations (Hagen–Poiseuille), Kinetic & momentum correction factors, Friction factor, roughness, Moody chart, Flow through fittings, contractions, enlargements, Compressible flow basics: Mach number, isentropic, adiabatic & isothermal flows, Nozzle flow, Flow through packed beds (Ergun's Equation)	20	9
4	<b>Fluid Machinery &amp; Transportation Systems:</b> Piping systems, joints, seals, Valves: Gate, Globe, Plug, Ball, Check, Pumps: positive displacement, centrifugal, Cavitation, priming, pump characteristics, Fans, blowers, compressors, Jet ejectors & vacuum pumps	23	10
5	<b>Flow Measurement &amp; Dimensional Analysis:</b> Flow meters: Venturi, orifice, rotameter, Coriolis, vortex, Pitot tubes, Magnetic & modern flow measurement devices, Dimensional analysis: Buckingham $\pi$ & other methods, Model studies	17	8
Total		<b>100%</b>	<b>45</b>

**i. Text Book and Reference Book:**

1. Fluid Mechanics, Frank. M. White | Tata McGraw Hill
2. Unit operations of Chemical Engineering, Warren L. McCabe, Julian C. Smith, Peter Harriott | Mc-Graw-Hill
3. Introduction to Fluid Mechanics, R.W. Fox A.T Mac Donald and P.J. Pritchard | Wiley
4. Incompressible Flow, R.L. Panton | 3rd Edition, Wiley-India 2005.

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- a. **Course Name:** Fluid Mechanics Lab
- b. **Course Code:** 03010303PC04
- c. **Prerequisite:** Basic Knowledge of Unit Operations, this course is to introduce the mechanics of fluids (fluid statics and fluid dynamics), relevant to Chemical Engineering operation
- d. **Rationale:** The course will introduce students to forces on fluids, hydrostatic forces on submerged bodies, Eulerian and Lagrangian descriptions of flow, flow visualization, integral analysis involving mass and momentum balances, Bernoulli equation, flow through pipes and ducts, flow measurement and instruments, flow transportation - pumps, blowers and compressors, conservation of mass, linear and angular momentum in differential form, Navier-Stokes equation, viscous flows, skin and form friction, lubrication approximation, potential flows and boundary layer theory.

e. **Course Learning Objective:**

<b>CLOBJ 1</b>	To enhance the students to apply Bernoulli's principle and flow measurement devices to determine fluid flow parameters
<b>CLOBJ 2</b>	To equip the students to analyze flow behavior in pipes and fittings by evaluating pressure drop, friction factor, and Reynolds number.
<b>CLOBJ 3</b>	To enable the students to distinguish between laminar, transitional, and turbulent flow using experimental visualization techniques.
<b>CLOBJ 4</b>	To equip the students to measure velocity and flow rate using primary and secondary measuring devices such as Pitot tube and V-notch.
<b>CLOBJ 5</b>	To enhance the students to demonstrate their understanding on the working principles, performance characteristics, and operational aspects of centrifugal and reciprocating pumps.

f. **Course Learning Outcome:**

<b>CLO1</b>	Apply Bernoulli's principle and flow measurement devices to determine fluid flow parameters
<b>CLO2</b>	Analyze flow behavior in pipes and fittings by evaluating pressure drop, friction factor, and Reynolds number.
<b>CLO3</b>	Distinguish between laminar, transitional, and turbulent flow using experimental visualization techniques.
<b>CLO4</b>	Measure velocity and flow rate using primary and secondary measuring devices such as Pitot tube and V-notch.
<b>CLO5</b>	Demonstrate understanding of the working principles, performance characteristics, and operational aspects of centrifugal and reciprocating pumps.

g. **Teaching & Examination scheme**

Teaching Scheme				Examination Scheme				
L	T	P	C	Internal Marks		External Marks		Total
Hrs/Week	Hrs/Week	Hrs/Week		CE	P	T	P	
0	0	2	1	10	15	0	25	50

h. **Course Content (List of Practicals)**

Sr. No.	Topics
1.	To study and verify Bernoulli Theorem
2.	To calibrate Venturi meter and obtain its coefficient of discharge
3.	To calibrate an Orifice meter and obtain its coefficient of discharge
4.	To calibration of a Rotameter
5.	Measurement of pressure drop across pipe fitting
6.	Friction factor vs Reynolds Number

7.	To study Reynolds Experiment Apparatus
8.	Measurement of flow through V-notch
9.	Study experiment using Virtual simulator

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- a. **Course Name:** Utilities in Chemical Process Plant
- b. **Course Code:** 03010303PC05
- c. **Prerequisite:** Basic knowledge of Chemical Engineering fundamentals, Thermodynamics, and Fluid Mechanics.
- d. **Rationale:** Utilities such as steam, water, refrigeration, compressed air, and power are essential for chemical plant operation. Their proper generation, distribution, and management affect safety, efficiency, and cost. This course builds fundamental understanding of utility systems used in process industries.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	To enable the students to explain the role and importance of utilities in chemical process plants.
<b>CLOBJ 2</b>	To enhance the students to describe steam generation, distribution, and condensate recovery systems.
<b>CLOBJ 3</b>	To enhance the students to analyze water treatment and cooling systems used in industries.
<b>CLOBJ 4</b>	To enable the students to understand refrigeration and compressed air systems in process operations.
<b>CLOBJ 5</b>	To equip the students to apply basic energy conservation and utility optimization principles in chemical plants.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Explain the role and importance of utilities in chemical process plants.
<b>CLO 2</b>	Describe steam generation, distribution, and condensate recovery systems.
<b>CLO 3</b>	Analyze water treatment and cooling systems used in industries.
<b>CLO 4</b>	Understand refrigeration and compressed air systems in process operations.
<b>CLO 5</b>	Apply basic energy conservation and utility optimization principles in chemical plants.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
2	0	0	2	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr.	Topics	Weightage (%)	Teaching (hr)	
1	<b>Introduction to Plant Utilities:</b> Importance of utilities in chemical industries, classification of utilities, utility flow diagrams, role in process economics, utility integration concepts.	20	6	

<b>2</b>	<b>Steam Generation and Distribution:</b> Types of boilers, boiler components and accessories, steam properties, steam traps, condensate recovery, steam distribution systems, insulation, steam economy and efficiency.	20	6	
<b>3</b>	<b>Water Systems in Process Plants:</b> Sources of water, water treatment methods, softening, demineralization, cooling water systems, cooling towers, blowdown, corrosion and scaling control.	20	6	
<b>4</b>	<b>Refrigeration and Compressed Air Systems:</b> Basics of refrigeration cycles, refrigerants, refrigeration equipment, applications in process industries, compressed air generation, compressors, air distribution, air dryers, safety and maintenance	20	6	
<b>5</b>	<b>Power and Fuel Systems:</b> Industrial power generation, fuels used in process plants, fuel handling and storage, energy conservation methods, waste heat recovery, utility optimization and safety considerations.	20	6	
<b>Total</b>		<b>100</b>	<b>30</b>	

**j. Text Book and Reference Book:**

1. Water Treatment for industrial and other uses, Reinhold Publishing Corporation, New York, 1961. Nordell, Eskel
2. Plant Utilities, Nirali Prakashan Publication, Dr. Mujawar
3. Plant Utilities, Nirali Prakashan Publication, D.B. Dhone
4. Thermal Engineering, Khanna Publisher, New Delhi, P.L. Balleney

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- a. **Course Name:** Heat Transfer
- b. **Course Code:** 03010303PC07
- c. **Prerequisite:** Basic knowledge of Engineering Physics, Engineering Mathematics, and Fluid Mechanics.
- d. **Rationale:** Heat Transfer is a fundamental core course in Chemical Engineering that provides the scientific basis for understanding how thermal energy is transported in process systems. Mastery of conduction, convection, radiation, and phase-change heat transfer is essential for analyzing and designing key process equipment such as heat exchangers, evaporators, condensers, dryers, and reactors. The course enables students to apply heat transfer principles, correlations, and design methods to real industrial problems, ensuring energy-efficient, safe, and economical operation of chemical processes.
- e. **Course Learning Objective:**

<b>CLOBJ 1</b>	To enable the students to explain the principles and fundamental laws governing conduction, convection, and radiation heat transfer.
<b>CLOBJ 2</b>	To enable the students to calculate heat transfer in one-dimensional steady and unsteady state conduction for solids with various geometries.
<b>CLOBJ 3</b>	To enhance the students to discuss heat transfer mechanisms under different convective regimes.
<b>CLOBJ 4</b>	To equip the students to describe radiation phenomena for different types of surfaces and their applications in thermal radiation systems.
<b>CLOBJ 5</b>	To enhance the students to examine heat transfer processes in various types of heat transfer equipment commonly used in chemical industries. Identify industrial applications and regimes associated with boiling and condensation processes.

**f. Course Learning Outcomes:**

<b>CLO 1</b>	Explain the principles and fundamental laws governing conduction, convection, and radiation heat transfer.
<b>CLO 2</b>	Calculate heat transfer in one-dimensional steady and unsteady state conduction for solids with various geometries.
<b>CLO 3</b>	Discuss heat transfer mechanisms under different convective regimes.
<b>CLO 4</b>	Describe radiation phenomena for different types of surfaces and their applications in thermal radiation systems.
<b>CLO 5</b>	Examine heat transfer processes in various types of heat transfer equipment commonly used in chemical industries. Identify industrial applications and regimes associated with boiling and condensation processes.

**g. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme					
L	T	P	C	Internal Evaluation			ESE		Total
				MSE	CE	P	Theory	P	
3	0	0	3	20	20	-	60	-	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

**h. Course Content:**

Sr.	Topics	Weightage (%)	Teaching (hr)
1	<b>Heat Transfer Fundamentals:</b> Modes of heat transfer, general laws of heat transfer, thermal conductivity, thermal resistance, thermal diffusivity, heat transfer coefficient, relationship of thermodynamics and heat transfer, differential equations of heat transfer, special forms	18	6
2	<b>Conductive heat transfer:</b> One-dimensional problem, heat transfer from extended surfaces, insulation, unsteady state heat transfer	20	10
3	<b>Convective heat transfer:</b> Natural and forced convection, Dimensional analysis, Thermal boundary layer; Analogies and Correlations	20	12
4	<b>Radiation:</b> Nature of radiation, radiation intensity, Planck's law, concept of black body and gray body, Transmissivity, Absorptivity, Reflectivity, Emissivity of black bodies and gray bodies. Application of thermal radiation	20	7
5	<b>Heat transfer equipment &amp; Boiling, Condensation and Evaporation:</b> Types of Heat Exchangers- double pipe heat exchanger, concept of LMTD, shell and tube heat exchanger, effectiveness-NTU method. Boiling phenomena, condensation, Condensers, Reboilers and Evaporators	22	10
Total		100%	45

**k. Text Book and Reference Book:**

1. Heat Transfer: A Practical Approach, McGraw-Hill Publication. Yunus A. Cengel
2. Heat Transfer, McGraw-Hill Publication. J. P. Holman
3. Process Heat Transfer, Tata McGraw-Hill Publication. D. Q. Kern
4. Fundamentals of Heat and Mass Transfer, Wiley Publication. Frank P. Incropera, David P. DeWitt
5. Heat Transfer: Principles and Applications, PHI Learning Publication. B. K. Dutta

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i. **Course Name:** Heat Transfer Lab

j. **Course Code:** 03010303PC06

k. **Prerequisite:** Basic knowledge of thermodynamics, fluid mechanics, and fundamental modes of heat transfer along with familiarity with temperature and flow measurement instruments.

l. **Rationale:** The Heat Transfer Laboratory bridges the gap between theory and real engineering practice by providing hands-on exposure to conduction, convection, radiation, and phase change heat transfer processes. Through experimentation, students learn how heat transfer coefficients are determined, how different materials respond to heat flow, how flow conditions affect convection, and how industrial heat exchangers perform under parallel and counter flow arrangements.

m. **Course Learning Objective:**

<b>CLOBJ 1</b>	To enable the students to conduct steady-state conduction experiments to measure the thermal conductivity of various materials.
<b>CLOBJ 2</b>	To enhance the knowledge of the students to determine heat transfer coefficients in free and forced convection and compare them with theoretical predictions.
<b>CLOBJ 3</b>	To enable the students to measure surface emissivity and validate Stefan-Boltzmann's constant through experiments.
<b>CLOBJ 4</b>	To enhance the ability of students to calculate the rate of heat transfer in different types of heat exchangers.
<b>CLOBJ 5</b>	To enable the students to evaluate steam economy in evaporators under varying operational conditions.

n. **Course Learning Outcome:**

<b>CLO1</b>	Conduct steady-state conduction experiments to measure the thermal conductivity of various materials.
<b>CLO2</b>	Determine heat transfer coefficients in free and forced convection and compare them with theoretical predictions.
<b>CLO3</b>	Measure surface emissivity and validate Stefan-Boltzmann's constant through experiments.
<b>CLO4</b>	Calculate the rate of heat transfer in different types of heat exchangers.
<b>CLO5</b>	Evaluate steam economy in evaporators under varying operational conditions.

o. **Teaching & Examination scheme**

Teaching Scheme				Examination Scheme				
L	T	P	C	Internal Marks		External Marks		Total
Hrs/Week	Hrs/Week	Hrs/Week		CE	P	T	P	
0	0	2	1	10	15	0	25	50

p. **Course Content (List of Practicals)**

Sr. No.	Topics
1.	To determine the thermal conductivity of a given composite wall
2.	To determine the heat transfer coefficient by forced convection
3.	To determine the heat transfer coefficient by natural convection
4.	To determine the emissivity of the test plate.
5.	To determine Stefan's Boltzmann constant.
6.	To calculate the LMTD, overall heat transfer coefficient and rate of heat transfer, in a double pipe heat exchanger.
7.	To calculate the LMTD, overall heat transfer coefficient and rate of heat transfer, in shell & tube heat exchanger.

8.	To determine overall heat, transfer co-efficient for finned tube type heat exchangers
9.	Study experiment using Virtual simulator

[8]

**a. Course Name: Theory of Complex Variable, Partial Differential Equations**

**b. Course Code: 03019103BS03**

**c. Prerequisite:** Geometry, Multivariable Calculus, Ordinary Differential Equations.

**d. Rationale:** - The course is designed to understand students the application of complex numbers and partial differential

**e. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	Theory	Total
3	0	0	3	20	20	-	60	100

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	Analytic Functions and Complex Integration: Cauchy-Riemann equations, Harmonic functions, Contours and line integrals, Cauchy-Goursat theorem, Cauchy's integral formula	30%	14
2	Series Representation, Residue Theory and Conformal Mapping: Taylor Series, Laurent series, singularities, residues, residue theorem, Mobius transformations	30%	14
3	Partial Differential Equations: Solutions of first order linear and nonlinear PDEs, classifications of PDE, separation of variables method	40%	17
Total		100%	45

**g. Text Book and Reference Book:**

1. Complex Variables and Applications (TextBook) – By J. W. Brown and Ruel V. Churchill | McGraw-Hill
2. Advanced Engineering Mathematics (TextBook) – By Erwin Kreyszig | Willey India Edition
3. Elements of Partial Differential Equations (TextBook) – By I. Sneddon | McGraw Hill
4. Elementary Applied Partial Differential Equations with Fourier Series and Boundary Value Problem – By R. Haberman | Prentice Hall | 4th Edition
5. A First Course in Complex Analysis with Applications – By D. G. Zill and P. D. Shanahan | Jones and Bartlett Publishers
6. Introduction to Partial Differential Equations – By Rao K. S. | PHI Learning Pvt. Ltd.

**h. Course Outcome:**

1. Analyse properties of complex variable functions.
2. Understand singularities, residues and residue theorem.
3. Solve linear PDEs using separation of variables and transform methods.

[9]

**a. Course Name: Functional Communication Skills**

**b. Course Code: 03010003HM01**

**c. Prerequisite:** Knowledge of Advanced Communication and Interpersonal Skills.

**d. Rationale:** This course develops workplace-oriented communication skills by bridging academic language competence with professional communication requirements.

**e. Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	Theory	Total
1	0	2	2	-	-	60	30	150

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Sentence Correction</b> Error identification (grammar, usage, style) Common workplace errors Contextual grammar usage	10%	2
2	<b>Para Jumbles &amp; Sentence Reordering</b> Logical sequencing Cohesion markers Theme identification	8%	1
3	<b>Statement and Assumptions</b> Fact vs assumption Logical reasoning basics Workplace problem scenarios	10%	1
4	<b>Reading Comprehension (Level of Difficulty - Advanced)</b> Inferential questions Author's tone & intent Vocabulary in context	12%	2
5	<b>Resume and Cover Letter Writing</b> Resume formats Achievement-based bullet points Customizing cover letters	14%	2
6	<b>Building a Professional LinkedIn Profile</b> Professional headline Summary writing Digital networking ethics	8%	1
7	<b>Just a Minute (JAM)</b> Idea organization Fluency techniques Time management in speech	8%	1
8	<b>Telephone and Video Call Etiquette</b> Opening & closing calls Voice modulation Virtual meeting etiquette	8%	1
9	<b>Email Writing</b> Format Professional tone Subject lines Email etiquette	10%	2
10	<b>Report Writing</b> Report Writing Types of reports Structure & formatting	12%	2

	<b>Use of visuals &amp; data</b>		
Total		100%	15

**g. ext Book and Reference Book:**

1. Business Communication Today – By Bovee, Courtland L., and John V. Thill | Pearson Education | 2019
2. Essentials of Business Communication – By Mary Ellen Guffey and Dana Loewy | Cengage Learning | 2018
3. Advanced Grammar in Use – By Martin Hewings | Cambridge University Press | 2013
4. English Vocabulary in Use: Advanced – By Michael McCarthy and Felicity O’Dell | Cambridge University Press | 2017
5. Personality Development and Soft Skills – By Barun K. Mitra | Oxford University Press | 2011
6. Technical Communication: Principles and Practice – By Meenakshi Raman and Sangeeta Sharma | Oxford University Press | 2018

**h. Course Outcome:**

1. Identify grammatical, usage, and style errors.
2. Understand grammatical rules and professional writing formats.
3. Apply principles of professional communication.
4. Analyse effective verbal, digital, and virtual communication skills.

## Semester 4

- a. **Course Name:** Mass Transfer-I  
 b. **Course Code:** 03010304PC01  
 c. **Prerequisite:** Basic knowledge of Heat Transfer, Fluid Mechanics and Engineering Mathematics.  
 d. **Rationale:** Mass Transfer-I provides the fundamental principles governing diffusion and interphase mass transport, which are essential for analysing and designing chemical and process industries. It builds a strong foundation for understanding separation processes and advanced transport operations.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
3	0	0	3	20	20	-	60	100

L- Lectures; T- Tutorial; P- Practical; C- Credit; MSE- Mid-Semester Evaluation, CE- Continuous Evaluation, ESE- End Semester Examination

f. **Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Introduction and Diffusion:</b> Definition and Classification of mass transfer operations, direct versus indirect operations, choice of separation method, methods of conducting mass transfer operations, Molecular Diffusion in Fluids: Molecular diffusion, eddy diffusion, Fick's law of molecular diffusion, N-flux and j-flux, steady state molecular diffusion in fluids at rest and in laminar flow, molecular diffusion and diffusivity of gases and liquids,	20	9
2	<b>Mass Transfer Coefficient and Interphase Mass Transfer:</b> Concept of Mass transfer coefficient, relation between mass transfer coefficients, film theory, penetration theory, surface renewal theory, combined film-surface renewal theory, surface stretch theory, analogies in transfer process, Dimensionless numbers, Equilibrium, diffusion between phases, local two-phase mass transfer, local overall mass transfer coefficient, material balances for co-current and counter current processes, concept of stages.	22	10
3	<b>Equipment for Gas-Liquid Operation &amp; Gas Absorption:</b> Tray towers, packed towers, comparison between tray towers and packed towers. Equilibrium solubility of gases in liquids, ideal and non-ideal solutions, choice of solvent for absorption, material balance for co-current and counter-current flow, minimum liquid gas ratio for absorption and stripping, absorption factor, concept of HETP and HTU, NTU, absorption with chemical reaction	22	10

4	<b>Distillation:</b> Vapor-liquid equilibria, positive and negative deviation from ideality, single stage operation-flash vaporization, differential distillation, constant relative volatility, continuous rectification for binary systems, feed tray location, optimum reflux ratio, multistage tray towers-method of Mc-Cabe and Thiele, introduction of feed, location of the feed tray, total reflux or infinite reflux ratio, minimum reflux ratio, optimum reflux ratio, azeotropic distillation, extractive distillation, comparison of azeotropic and extractive distillation.	<b>22</b>	<b>10</b>
5	<b>Crystallization:</b> Principle of crystallization, applications of crystallization, saturation and equilibria, nucleation, crystallization rate, Crystal size distribution, Caking of crystals, crystallization equipment.	<b>14</b>	<b>6</b>
Total		100%	45

**g. Text Book and Reference Book:**

1. Principles of Mass transfer and Separation Process Dutta, B.K., 2007 | Prentice-Hall of India Pvt. Ltd., New Delhi
2. Mass Transfer Operations R. E. Treybal | Mc-Graw-Hill
3. Diffusion - Mass Transfer in Fluid Systems, E.D. Cussler, |Cambridge University Press, Cambridge 1984
4. Principles of Unit Operations, S. Foust, | 2nd Edition, Wiley, New York, 1980.
5. Transport Processes and Unit Operations, C.J. Geankoplis, | 3rd Edition, Prentice Hall, India, 1993.

**h. Course Outcome:**

1. Explain mass transfer operations and apply Fick's law to analyze molecular diffusion in gases and liquids.
2. Apply mass transfer theories to analyze interphase mass transfer and determine local and overall mass transfer coefficients.
3. Analyze gas-liquid absorption processes using tray and packed towers through material balances and HTU-NTU concepts.
4. Analyze vapor-liquid equilibrium data and design binary distillation columns using the McCabe-Thiele method.
5. Explain crystallization principles and evaluate crystallizer performance based on nucleation and growth mechanisms.

- a. **Course Name:** Mass Transfer Lab  
 b. **Course Code:** 03010304PC02  
 c. **Prerequisite:** Basic understanding of Fluid Mechanics, Heat Transfer and Engineering Mathematics, along with familiarity with basic laboratory instruments, data analysis, and experimental safety practices.  
 d. **Rationale:** Mass Transfer–I Lab bridges theory with practice by enabling students to experimentally study diffusion and mass transfer operations. It builds analytical skills and practical competence essential for chemical engineering applications.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
0	0	2	1	-	20	-	30	50

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. List of Experiments:**

1.	To determine the diffusivity of liquid in stagnant air different temperatures.
2.	To determine diffusivity of liquid in air as a function of Temperature using Arnold Diffusion cell.
3.	To determine diffusivity of liquid in air by providing blowing air using Arnold Diffusion cell.
4.	To determine mass transfer coefficient using wet and dry bulb temperature.
5.	Separation of binary mixture using Steam Distillation.
6.	To generate the vapor liquid equilibrium data for a given binary mixture.
7.	To perform Gas absorption in packed column.
8.	To perform crystallization without seeding.
9.	To perform crystallization with seeding.
10.	Study and Virtual Experiments

**g. Course Outcome:**

1. Perform experiments to determine diffusivity and analyze the effect of temperature and flow conditions on mass transfer rates.
2. Evaluate mass transfer coefficients using experimental techniques such as wet-bulb and dry-bulb methods.
3. Conduct separation processes including distillation, gas absorption, and crystallization, and interpret the results.
4. Apply vapor–liquid equilibrium and phase equilibrium concepts to generate and analyze experimental data.
5. Demonstrate proficiency in laboratory practices, data analysis, report writing, and safe operation of mass transfer equipment.

- a. **Course Name:** Thermodynamics-I  
 b. **Course Code:** 03010304PC03  
 c. **Prerequisite:** Basic knowledge of physics, chemistry, engineering mathematics, units, and mole concept.  
 d. **Rationale:** Thermodynamics-I builds the fundamental understanding of energy, heat, work, and properties of matter, which forms the basis for analyzing and designing all chemical engineering processes and equipment.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
3	1	0	4	20	20	-	60	100

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Introduction &amp; First Law of Thermodynamics:</b> Scope of thermodynamics, Dimensions and Units, Temperature, Pressure, Work, Energy, Heat & Energy conservation & first law of thermodynamics; State functions; Equilibrium; Phase Rule; Reversible process; Constant P,V, T processes; Mass and energy balances for open systems	25	15
2	<b>Properties of Pure Substances:</b> Phases, phase transitions, PVT behaviour; description of materials & minus; Ideal gas law, Reduced conditions & corresponding states theories; correlations in description of material properties and behavior	15	9
3	<b>Heat Effects:</b> Heat effects-latent heat, sensible heat, standard heats of formation, reaction and combustion	10	6
4	<b>Second Law of Thermodynamics:</b> Statements of the second law; Heat engines, Carnot's theorem,; Thermodynamic Temperature Scales; Entropy; Entropy changes of an ideal gas; Mathematical statement of the second law; Entropy balance for open systems; Calculation of ideal work, Lost work, Third Law of Thermodynamics	20	12
5	<b>Applications of Laws of Thermodynamics :</b> Application of thermodynamics to flow processes-pumps, compressors and turbines, Thermodynamic analysis of steam power plants; Rankine cycle, Internal combustion engine, Otto engine; Diesel engine; Jet engine, The Carnot refrigerator; Vapor-compression cycle; Absorption refrigeration; Heat pump, Liquefaction processes	30	18
Total		100%	60

**g. Text Book and Reference Book:**

1. Introduction to Chemical Engineering, Thermodynamics, J.M. Smith, H.C. Van Ness and M.M. Abbott, | 7th edition, McGraw-Hill International Edition, 2005.
2. A text book of Chemical Engineering Thermodynamics, K. V. Narayanan | Prentice-Hall

of India Pvt. Ltd.

3. Principles of Engineering Thermodynamics, M J Moran, H N Shapiro, D D Boettner and M B Bailey, | Willey | 8th
4. Introduction to Thermodynamics, Y.V.C. Rao; | Wiley Eastern Limited

**h. Course Outcome:**

1. Establish a fundamental of the basic principles of thermodynamics and associated calculations.
2. Utilize mass and energy balances for both closed and open systems
3. Implement heat effects and the second law of thermodynamics in chemical engineering applications.
4. Examine the thermodynamic properties of non-ideal gases using the equation of state (EOS).
5. Discuss chemical process equipment like turbines, compressors, and heat pumps using thermodynamic principles

- a. **Course Name:** Numerical Methods in Chemical Engineering  
 b. **Course Code:** 03010304PE01  
 c. **Prerequisite:** Mathematics, Basic knowledge of various unit Operations and unit processes.  
 d. **Rationale:** This course equips students with mathematical tools to solve complex chemical engineering problems that lack analytical solutions. It focuses on numerical approximations for algebraic and differential equations, enabling the modeling of physical phenomena like reaction kinetics and heat transfer.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
4	0	0	4	20	20	-	60	100

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Interpretation of Engineering Data:</b> Curve fitting: Least square regression. Interpolation: Newton's Forward/Backward interpolation, Lagrange's interpolation and their applications.	15	9
2	<b>Numerical Solution of Algebraic Equations:</b> Linear systems of equations, Solutions by Cramer's Rule, Matrix methods, Gauss-Jordan, Gauss Elimination, Gauss Jacobi, Gauss-Seidel and Relation methods. Non-linear equations: Bisection, Regula-falsi, Secant and Newton- Raphson methods.	15	9
3	<b>Numerical integration:</b> Trapezoidal rule, Simpson's rule, integration with unequal segments, quadrature methods, Chemical engineering problems involving numerical differentiation and integration.	20	12
4	<b>Numerical Solution of Differential Equations:</b> Initial value problems for ordinary differential equations: Euler's, Runge-Kutta and Milne's predictor-corrector methods. Boundary value problems: Finite difference methods, Partial differential equations: Solutions of elliptic, parabolic and hyperbolic types of equations.	25	15
5	<b>Formulation of Physical Problems:</b> Mathematical statement and representation of problems, Exponential growth and decay, Newton's law of cooling, Batch reaction kinetics, Radial heat transfer through a cylindrical conductor, salt accumulation in a stirred tank, Regression and Data Analysis	25	15
Total		100%	60

**g. Text Book and Reference Book:**

- Numerical Methods for Engineers, New Academic Science, 2012, S.K. Gupta.
- Numerical Methods for Engineers with Personal Computer Applications, McGraw Hill Book Company, 1985, S.C. Chapra & R.P. Canale
- Numerical Analysis, Brooks Coles, 2000, R.L. Burden & J. D. Faires.
- An Introduction to Numerical Analysis, John Wiley & Sons, 1978, K.E. Atkinson.

5. Introduction to Numerical Methods in Chemical Engineering, PHI Learning Private Limited, 2019, Pradeep Ahuja.
6. Introductory Methods of Numerical Analysis, PHI Learning Private Limited, 5th Edition, 2012, S.S. Sastry.

**h. Course Outcome:**

1. Apply numerical techniques to interpret engineering data through curve fitting and interpolation.
2. Solve linear and non-linear algebraic equations using various matrix and iterative methods.
3. Execute numerical integration and differentiation for chemical engineering problems.
4. Formulate and solve initial and boundary value problems for ordinary and partial differential equations.

- a. **Course Name:** Biochemical Engineering  
 b. **Course Code:** 03010304PE03  
 c. **Prerequisite:** Basic concepts of chemistry and unit operations..  
 d. **Rationale:** This course aims to introduce students to the fundamentals of biochemical engineering, highlighting the integration of biological systems with engineering principles. The course covers microbial systems, enzyme kinetics, bioreactors, and downstream processing techniques.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
4	0	0	4	20	20	-	60	100

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Introduction to Biochemical Engineering &amp; Cell Biology</b> Scope and interdisciplinary nature of biochemical engineering, Comparison of chemical vs biochemical processes, Integrated bioprocess systems, Unit operations in bioprocess industries, Fundamentals of microbiology, Prokaryotic and eukaryotic cells – structure and comparison, Chemicals of life: carbohydrates, proteins, lipids (basic overview).	16	10
2	<b>Enzymes and Enzyme Kinetics</b> Characteristics of enzymatic reactions, Enzyme–substrate interaction models, Factors influencing enzyme activity, Michaelis–Menten kinetics: derivation and graphical interpretation, Enzyme inhibition, Enzyme immobilization techniques, Industrial enzymes and applications.	20	13
3	<b>Microbial Growth, Stoichiometry &amp; Bioreaction Kinetics</b> Media preparation and sterilization methods, Cell death kinetics, Stoichiometry of microbial growth and product formation, Yield coefficients, degree of reduction, respiratory quotient, Microbial growth phases, Measurement of microbial growth, Monod growth kinetics, Evaluation of kinetic parameters.	22	13
4	<b>Bioreactors and Fermentation Technology</b> Batch, fed-batch, and continuous culture systems Stirred tank reactors, reactors in series, and recycle reactors, Plug flow reactor, Fermentor design and construction, Aseptic conditions and control of parameters, Aeration and agitation, Oxygen transfer and determination of $K_La$ , Fluid rheology and factors affecting mass transfer.	22	12

5	<b>Downstream Processing of Bioproducts</b> Product recovery and purification strategies, Filtration and centrifugation, Cell disruption techniques, Liquid-liquid extraction, Microfiltration and ultrafiltration, Chromatography, Electrophoresis and isoelectric focusing.	20	12
Total		100%	60

**g. Text Book and Reference Book:**

1. Biochemical Engineering Fundamentals, James E. Bailey & David F. Ollis
2. Elements of Chemical Reaction Engineering, H. Scott Fogler
3. Bioprocess Engineering: Basic Concepts, Michael L. Shuler & Fikret Kargi
4. Introduction to Biochemical Engineering, D. G. Rao, B. K. Sharma

**h. Course Outcome:**

1. Explain the fundamental concepts of biochemical reactions and stoichiometry.
2. Describe microbial structures, growth, and functions in biochemical systems.
3. Analyze design principles and operations of bioreactors.
4. Illustrate downstream processing techniques for bioproduct recovery.
5. Apply enzyme kinetics concepts to industrial biochemical applications.

- a. **Course Name:** Bioprocess Engineering  
 b. **Course Code:** 03010304PE03  
 c. **Prerequisite:** Basic concepts of heat transfer, mass transfer and reaction kinetics.  
 d. **Rationale:** This course equips students with fundamental principles of bioprocesses and bioreactor operations, enabling them to apply chemical engineering concepts to the production of value-added biological products in pharmaceuticals, food, environmental, and biotechnology industries.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
4	0	0	4	20	20	-	60	100

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Introduction:</b> Classification of cells; Cell Construction; Cell Nutrients, Media classification, biomolecules.	10	4
2	<b>Overview of Biological Basics:</b> Bioenergetics; Glycolysis; TCA Cycle; Respiration; Control Sites in Aerobic Glucose Metabolism; Overview of Biosynthesis; Overview of Anaerobic Metabolism; Overview of Autotrophic Metabolism; Metabolic Regulations.	25	9
3	<b>Microbial Growth:</b> Batch Growth; Quantifying growth kinetics; Continuous growth, types of microbial inhibition and their kinetics, Stoichiometry of microbial growth and product formation.	18	8
4	<b>Bioreactors:</b> Introduction to bioreactors; Batch and fed-batch bioreactors; Continuous bioreactors; Bioreactor operation; Immobilized Cell Systems; Sterilization; Aeration.	16	8
5	<b>Bio separations:</b> Biomass removal; Biomass disruption; Membrane based techniques; Extraction; Adsorption and Chromatography.	16	8
6	<b>Industrial Processes:</b> Description of industrial processes- aerobic and anaerobic fermentations and products, Process flow diagrams	15	8
Total		100%	45

**g. Text Book and Reference Book:**

1. Bioprocess Engineering: Basic Concepts, Shuler, M.L., and Kargi, F., Prentice Hall, 2001.
2. Biochemical Engineering, Aiba, S., Humphrey, A.E., and Mills, N.F., 2nd edition, Academic Press, New York, 1973.
3. Biochemical Engineering Fundamentals, Bailey, J.E., Ollis, D.F., 2nd ed., McGraw Hill, 1986.
4. Biochemical Reactors, Pion Ltd., by Atkinson, B., London, 1974

5. Separation for Biotechnology, Pyle, D.L ,Royal Society of Chemistry, Cambridge, 1994.

**h. Course Outcome:**

1. Explain cellular organization, biomolecules, and metabolic pathways.
2. Analyse microbial growth behaviour, kinetics, and stoichiometry.
3. Understand transport phenomena in biological reactors.
4. Apply biochemical engineering principles to operate bioreactors.
5. Select appropriate bio separation techniques and industrial bioprocesses.

- a. **Course Name:** Fuels and Combustion  
 b. **Course Code:** 03010304PE07  
 c. **Prerequisite:** Material and Energy Balance Calculations.  
 d. **Rationale:** This course provides fundamental knowledge of fuels, combustion principles, and energy conversion processes essential to chemical engineering practice. It equips students with the ability to analyse combustion systems, perform practical calculations, and address energy efficiency and environmental issues in industrial applications.  
 e. **Teaching & Examination Scheme:**

Teaching Scheme				Evaluation Scheme				
L	T	P	C	MSE	CE	P	ESE	Total
4	0	0	4	20	20	-	60	100

**L-** Lectures; **T-** Tutorial; **P-** Practical; **C-** Credit; **MSE-** Mid-Semester Evaluation, **CE-** Continuous Evaluation, **ESE-** End Semester Examination

**f. Course Content:**

Sr. No.	Content	Weightage (%)	Teaching Hours
1	<b>Introduction:</b> Present situation and global Consumption of fuels, Classification of fuels, Solid, liquid and gaseous fuels, Properties of fuels and their measurement techniques.	10	6
2	<b>Solid and Liquid Fuels:</b> Coal origin, its types, properties and consumption, Coal mining, Coal combustion and combustion techniques, coal gasification, oxidation and hydrogenation, Effective use of solid fuels. Origin and classification of petroleum, Petroleum refining, Testing and properties of petroleum products, Liquid fuels from other sources, storage and handling of liquid fuels.	30	18
3	<b>Gaseous Fuels:</b> Types of gaseous fuel, natural and and methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, cleaning and purification of gaseous fuels,	15	10
4	<b>Manufactured fuels:</b> Agro fuels, solid fuel handling, properties related to combustion, handling, and storage. bio-Fuels: types of bio-fuels, production processes and technologies, Bio-fuel applications.	15	8
5	<b>Combustion Technology:</b> Combustion stoichiometry and thermodynamics, calculation of heat of combustion, theoretical & actual combustion processes - air fuel ratio, estimation of dry and wet flue gases for known fuel composition, calculation of the composition of fuel & excess air supplied, flue gas analysis.	30	18
Total		100%	60

**g. Text Book and Reference Book:**

1. Irvin Glassman, "Combustion" 2nd ed., Academic Press

2. John Griswold, "Fuels Combustion and Furnaces" Mc-Graw Hill Book Company Inc.
3. S.P. Sharma & Chander Mohan, "Fuels & Combustion", Tata McGraw Hill Publishing Co. Ltd.
4. Rao, B.K.B., "Modern Petroleum Refining Processes", 4th ed., Oxford & IBH Publishing Co. Pvt. Ltd, 2018
5. Sarkar, S., "Fuels and Combustion", 3rd. ed., Universities Press, 2009.
6. Gupta O.P, "Elements of Fuels, Furnaces & Refractories", 3rd ed., Khanna Publishers.

**h. Course Outcome:**

1. Discuss energy resources, global energy consumption, fundamentals of combustion
2. Describe origin, classification, analysis, properties of solid, liquid, gaseous fuels and their applications
3. Solve combustion stoichiometry and thermodynamics problems
4. Discuss production processes and technologies of Agro and Bio fuels and their applications
5. Explain the social and environmental responsibility of engineers in the global community