SAHRDAYA AUTONOMOUS
COLLEGE OF ENGINEERING & TECHNOLOGY
A CENTRE OF EXCELLENCE IN SCIENCE & TECHNOLOGY | MANAGED BY IRINJALAKUDA DIOCESAN EDUCATION TRUST
Approved by AICTE & Affiliated to APJ Abdul Kalam Technological University | Accredited by:
Estd.2002

B. Tech
Curriculum and Syllabus (2024)
Semester III & IV
Biotechnology

Branch Code: BT

(SHR/AC/Auto/ Acad. Council /B.Tech/3/Syll./BT/S3-S4)

Recommended by BoS on 10/06/2025
Approved by Academic Council on 05/07/2025

THIRD SEMESTER (July-December)												
Sl. No	**Slot**	**Course Code**	**Course Type**	**Course Title (Course Name)**	**Credit Structure**				**Total Marks**		**Credits**	**Hrs./ Week**
					L	**T**	**P**	**R**	**CIA**	**ESE**		
1	A	24MAT321	BSC	Complex Analysis & Partial Differential Equations	3	0	0	0	40	60	3	3
2	B	24BTT302	PCC	Biochemistry	3	1	0	0	40	60	4	4
3	C	24BTT303	PCC	Microbiology	3	1	0	0	40	60	4	4
4	D	24BTR304	PCC-PBL	Industrial Bioprocess Technology	3	0	0	1	50	50	4	4
5	E	24HUT005	HMC	Engineering Economics	2	0	0	0	50	50	2	2
6	F	24EST306	ESC	Applied Data Science & Artificial Intelligence	3	1	0	0	40	60	4	4
7	L	24BTL307	PCL	Biochemistry Lab	0	0	3	0	50	50	2	3
8	Q	24BTL308	PCL	Microbiology Lab	0	0	3	0	50	50	2	3
9	J*	24SEK10N	SEC	Skill Enhancement Course 3							1	
10	R/M	24BTG3XX	VAC	Remedial/ Minor							4*	4*
Total											**26/ 30***	**27/ 31***

FOURTH SEMESTER (January-June)												
Sl. No:	**Slot**	**Course Code**	**Course Type**	**Course Title (Course Name)**	**Credit Structure**				**Total Marks**		**Credits**	**Hrs./ Week**
					L	**T**	**P**	**R**	**CIA**	**ESE**		
1	A	24MAT421	BSC	Probability Distributions, Numerical Methods & Transforms	3	0	0	0	40	60	3	3
2	B	24BTT402	PCC	Cell Biology and Genetics	3	1	0	0	40	60	4	4
3	C	24BTT403	PCC	Fluid Flow and Particle Technology	3	1	0	0	40	60	4	4
4	D	24BTR404	PCC-PBL	Chemical and Biological Reaction Engineering	2	1	0	1	50	50	4	4
5	F	24BTE41N	PEC	PE-1	3	0	0	0	40	60	3	3
6	L	24BTL406	PCL	Instrumental Methods of Analysis Lab	0	0	3	0	50	50	2	3
7	Q	24BTL407	PCL	Fluid Flow and Particle Technology Lab	0	0	3	0	50	50	2	3
8	I*	24PWT208	PW	UHV II: Life Skills and Community work	1	0	0	0	100	---	1	1
9	J*	24SEK10N	SEC	Skill Enhancement Course 4							1	
10	R/M/H	24BTG4XX/ 24BTH4XX	VAC	Remedial/Minor/Honours							4*	4*
Total											**24/ 28***	**25/ 29***

PROGRAM ELECTIVE I: 24BTE41N

Slot	Course Code	Courses	L-T-P-R	Hours	Credit
F	24BTE 411	Enzyme Engineering And Technology	3-0-0-0	3	3
	24BTE412	Food Safety And Quality Management	3-0-0-0		3
	24BTE 413	Bioenergy And Biofuels	3-0-0-0		3
	24BTE414	Biochemical Thermodynamics	3-0-0-0		3
	24BTE415	Biophysics	3-0-0-0		3
	24BTE416#	Analytical Techniques In Biotechnology	3-1-0-1	6	5

 # Higher credit elective

SEMESTER-III
SYLLABUS

24MAT321	COMPLEX ANALYSIS & PARTIAL DIFFERENTIAL EQUATIONS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
The course enables the students to understand basic concepts and tools of Partial Differential equations and Complex Analysis. Topics like Partial Differential Equations, Complex Integration and Residues are included. This course helps the learners to model and analyze physical phenomena involving continuous changes of variables or parameters with the help of modern tools and has applications across all engineering domains.

Prerequisite: A basic course in multivariable calculus and complex numbers.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Solve partial differential equations which are widely used in different engineering situations, modeling and applying partial differential equations in the analysis of various physical phenomena. **[Apply]**
CO 2	Apply complex variables and conformality to transform functions from one domain to another. **[Apply]**
CO 3	Apply indefinite integration and substitution of limits in the context of complex functions, integrating over paths and contours in the complex plane. **[Apply]**
CO 4	Apply residue theory to solve real integrals and how this connection enhances the evaluation of integrals in both real and complex domains. **[Apply]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3					2			2
CO2	2	3									2
CO3	3	3									2
CO4	3	3									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze				
Evaluate				
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]				
	Attendance	Assignment	Test-1	Test-2	Total Marks
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hours
End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Partial Differential Equations & Applications [9h]

(Text 2-Relevant portions of sections 17.1, 17.2, 17.3, 17.4, 17.5,18.2,18.3,18.4, 18.5)

Partial differential equations, Formation of partial differential equations –elimination of arbitrary constants andf arbitrary functions, Solutions of partial differential equations- Equations solvable by direct integration, Linear equations of the first order- Lagrange's linear equation, Solution of equation by method of separation of variables, One- dimensional wave equation- vibrations of a stretched string, One- dimensional heat equation (problems only)

Self -Study(14h):

1. Derivation of PDEs from real-world physics problems (e.g., heat equation, wave equation)
2. Relevance of PDE in your branch of study.
3. Narrate different methods to solve nonlinear equations with examples.
4. Review three or four of the most important PDEs and their main applications.
5. Solve five problems by the method of separation of variables.

MODULE II: Complex Variable – Differentiation [9h]

(Text 1: Relevant portions of sections 13.3, 13.4, 17.1, 17.2 , 17.4)

Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations, harmonic functions, finding harmonic conjugate, Conformal mappings- w = z^2 , w = e^z , w = $\frac{1}{z}$, w

= sinz (problems based on these transformations need to be discussed)

Self -Study (13h):

1. Write some analytic functions with proof.
2. Write notes on Mobius transformations with examples.
3. Discuss the conformal mapping of cos z.
4. Write the properties of the Inversion w = $\frac{1}{z}$.
5. Solve five problems using the Cauchy-Riemann equations.

MODULE III: Complex Variable – Integration [9h]

(Text 1- Relevant topics from sections 14.1, 14.2, 14.3, 14.4)

Complex integration, Line integrals in the complex plane, Indefinite integration and substitution of limit, Contour integrals, Cauchy's integral theorem (without proof) on simply connected and multiply connected domain, Cauchy Integral formula (without proof), Cauchy Integral formula for derivatives of an analytic function.

Self-Study(14h):

1. Write the basic properties of a complex line integral.
2. Integrate f(z) counterclockwise around the unit circle. Indicate whether Cauchy's integral theorem applies. Show the details: f(z) = 1/ (2z - 1).
3. Review the situations where Cauchy's integral formula and theorem are used in problems with suitable examples.
4. Solve five problems using Cauchy's integral formula.

MODULE IV: Complex Variable – Residue Integration [9h]

(Text 1- Relevant topics from sections 16.2, 16.3,16.4)

Zeros of analytic functions, singularities, poles, removable singularities, essential singularities, Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral using residue theorem, Residue integration of real integrals – integrals of rational functions of $cos\theta$ and $sin\theta$**.**

Self-Study(13h):

1. Importance of singularities in your branch of study.
2. Solve five problems using the concept of poles.
3. Write a few examples for Laurent's series.
4. Explain the process of solving improper integrals with examples.

Textbooks

1. E. Kreyszig, *Advanced Engineering Mathematics*, 10th ed., John Wiley & Sons, 2016.
2. B. S. Grewal, *Higher Engineering Mathematics*, 43rd ed., Khanna Publishers, 2015.

Reference books

1. P. V. O'Neil, *Advanced Engineering Mathematics*, 7th ed., Cengage Learning, 2012.

NPTEL/SWAYAM Courses for reference:

1. K. Nandakumaran, "Complex Analysis," NPTEL, IIT Madras, 2020. [Online]. Available: https://archive.nptel.ac.in/courses/111/106/111106141/
2. T. E. Venkata Balaji, "Advanced Complex Analysis – Part 1," NPTEL, IIT Madras, 2020. [Online]. Available: https://archive.nptel.ac.in/courses/111/106/111106084/

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	Partial differential equations, Formation of partial differential equations –elimination of arbitrary constants	1
1.2	Formation of partial differential equations -elimination of arbitrary functions	1
1.3	Solutions of partial differential equations-Equations solvable by direct integration	1
1.4	Linear equations of the first order- Lagrange's linear equation	1
1.5	Solution of equation by method of separation of variables	1
1.6	One- dimensional wave equation- vibrations of a stretched string	2
1.7	One- dimensional heat equation	2
	MODULE II [9 hours]	
2.1	Complex function, limit, continuity, derivative, analytic functions	1
2.2	Cauchy-Riemann equations	2
2.3	Harmonic functions, finding harmonic conjugate	2
2.4	Conformal mappings- mappings $w = z^2$	1
2.5	Conformal mappings- $w = e^z$	1
2.6	Conformal mappings - $w = \frac{1}{z}$	1
2.7	Conformal mappings- w = sin z	1
	MODULE III [9 hours]	
3.1	Complex integration, Line integrals in the complex plane	1
3.2	Indefinite integration and substitution of limit	1
3.3	Contour integrals, Cauchy's integral theorem (without proof) on simply connected connected domain	2
3.4	Contour integrals, Cauchy's integral theorem (without proof) on multiply connected domain	1
3.5	Cauchy Integral formula (without proof)	2
3.6	Cauchy Integral formula for derivatives of an analytic function	2
	MODULE IV [9 hours]	
4.1	Zeros of analytic functions	1
4.2	Singularities, poles	1

4.3	Removable singularities, essential singularities	1
4.4	Residues	1
4.5	Cauchy Residue theorem (without proof)	1
4.6	Evaluation of definite integral using residue theorem	2
4.7	Residue integration of real integrals – integrals of rational functions of $cos\theta$ and $sin\theta$	2

CO Assessment Questions

CO-1	1. Form the PDE by eliminating the arbitrary function 'f' from the equation z = f(x-y). **(Apply)** 2. Solve the one-dimensional heat equation subject to the initial condition u(x,0)= $\sin^2 x$. **(Apply)** **Team Work**: Discuss and present solutions to PDEs, highlighting the physical significance and applications of the results.
CO-2	1. Show that if u is harmonic and v is a harmonic conjugate of u, then u is a harmonic conjugate of -v.**(Understand)** 2. Why do the images of the straight lines x=constant and y=constant under a mapping by an analytic function intersect at right angles? The same question for the curves $\|z\| = constant$ and Arg z = constant. Are there exceptional points? **(Apply)** 3. Find the fixed point of w =a z +b **(Understand)** **Team Work:** As a group, analyze the behavior of the transformation w=1/z on different regions in the complex plane, such as the upper half-plane and the unit disk. What are the effects on these regions under the transformation?
CO-3	1. What is the significance of Cauchy's Integral Theorem for integrals over closed paths in a simply connected domain? **(Apply)** 2. Evaluate the indefinite integral of the complex function f(z)= e^{2z} and express the result in terms of z.**(Apply)** 3. Integrate counterclockwise around the unit circle $\oint_C \frac{Sin\, z}{z^4}$ dz **(Apply)** **Team Work:** In your group, work together to prove that for an analytic function f(z), the integral ∫f(z) dz= 0 for any closed path C inside a simply connected domain.
CO-4	1. Evaluate the integral $\int_0^{2\pi} \frac{d\theta}{3-2cos\theta}$ **(Apply)** 2. Consider the function f(z)= $\frac{1}{z^2+1}$. Identify and classify the singularities of this function. **(Analyze)** **Team Work:** Investigate the function f(z)= $\frac{z^2+1}{(z-1)(z+2)}$. Identify and classify all singularities of the function.

Prepared by: Ms Rani Thomas, Asst. Professor, Department of Applied Science & Humanities

24BTT302	BIOCHEMISTRY	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:
This course introduces the biochemical foundation of life with a focus on biomolecules, metabolism, and clinical relevance. Students will explore key metabolic pathways, inborn errors, and diagnostic markers that bridge biochemistry with human health. Emphasis is placed on understanding the molecular basis of disease and its significance in biotechnology and clinical practice.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Comprehend the structure, classification, and biological significance of key biomolecules and their roles in physiological processes. **[Apply & Analyze]**
CO 2	Discern major metabolic pathways of carbohydrates, lipids, proteins, and nucleotides, including their regulation and associated disorders. **[Apply]**
CO 3	Analyze the biochemical basis of inborn errors of metabolism and their clinical manifestations. **[Analyze]**
CO 4	Interpret clinical biochemical parameters and diagnostic markers used in disease detection and management. **[Apply]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1		2	2								2
CO2		2	2								2
CO3	3	3	2	3			3				3
CO4	3	3	3	3			3				3

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Lecture [L]				
	Attendance	Assignment	Test-1	Test-2	Total Marks
3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours
End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions; each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 subdivisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Biomolecules 12h[9L+3T]

Biomolecules: Introduction to biochemistry: scope, relevance to biotechnology - Chemical foundations: pH, buffers, water as a biological solvent. Biomolecules: classification, structure, and function. Glycosidic bonds, peptide bonds, and phosphodiester bonds. Glycosaminoglycans (hyaluronic acid, heparan sulfate, and Keratan Sulphate) and their significance. Lipids: Membrane lipids, Cholesterol, Prostaglandins, and Leukotrienes (functions only). Proteins: Levels of protein organization. Significance (only) of Ramachandran's plot. Functional proteins: Basic structure of haemoglobin, collagen, and insulin. Blood group substances. Nucleic acids: DNA and RNA structure and types.

Tutorial:

Biological buffers, Significance of GAGS; Organizational level of proteins - practical approach – Urea denaturation and renaturation; Blood grouping – How to find out the blood groups.

Self-Learning (18h):

1. Learning to discern the parameters in a blood report
2. Enzyme substrate reaction – Chymotrypsin, Ribonuclease, lysozyme
3. Blood parameters in diabetes and hypo/hyperlipidemia. Hypo/Hyper thyroidism

MODULE II: Metabolism 14h[10L+4T]

Metabolism- ATP - the energy currency. Carbohydrate Metabolism: Glycolysis, Substrate level phosphorylation, gluconeogenesis and Cori cycle, regulation. Citric Acid Cycle: energy yield, regulation. Electron Transport Chain, oxidative phosphorylation, mitochondrial diseases. Pentose Phosphate Pathway and oxidative stress. **Lipid Metabolism**: β-oxidation of fatty acids, ketone bodies. **Protein Metabolism**: Transamination, deamination, urea cycle. **Nucleotide Metabolism**: Biosynthesis and degradation of purines and pyrimidines (only salvage pathway)

Tutorial:

"Understanding Glycolysis": Step-by-step discussion of glycolysis with emphasis on key enzymes, substrate-level phosphorylation, and ATP yield; "ETC & Oxidative Phosphorylation: Powerhouse Breakdown": Diagram-based tutorial explaining complex I-IV and ATP synthase function; Anaplerotic and Cataplerotic Reactions": Understand how the TCA cycle connects to other metabolic pathways.

Self-Study (18h):

1. Understand ATP synthesis and usage. Watch a short animation/video + review textbook (Lehninger/Biochemistry by Berg). Create a table comparing the ATP yield from glycolysis, the TCA cycle, and the electron transport chain (ETC).
2. Gluconeogenesis & Regulation: Gluconeogenesis & Regulation
3. ETC Pathway: Labelled diagram construction + animation viewing.
4. β-Oxidation of Fatty Acids: Draw the Carnitine Shuttle. Problem-solving – calculate ATP yield.
5. Transamination & Deamination: Concept map of nitrogen handling. Urea Cycle- link to other metabolic pathways
6. Connect all pathways when each is active.

MODULE III: Inborn errors of metabolism 10h[6L+4T]

Inborn errors of metabolism: Definition and historical perspective. Defects in carbohydrate metabolism: Diabetes, Lactose Intolerance, Hereditary Fructose Intolerance, Glycogen storage diseases (Von Gierke Disease & Pompe Disease). Defects in lipid metabolism: hypercholesterolemia, hypo- and lipoproteinemia, Lysosomal Storage Disorders. Defects in amino acid metabolism: Phenylketonuria, Tyrosinosis, Albinism, Alkaptonuria, Maple syrup urine disease, Hartnup disease. Defects in nucleotide metabolism: Lesch-Nyhan Syndrome, Gout, Adenosine Deaminase (ADA) Deficiency.

Tutorial:

Garrod's work and concept of "one gene–one enzyme." Assign each group one disorder (e.g., PKU, Von Gierke, Tay-Sachs, Lesch-Nyhan). Explanation; Defects in Nucleotide Metabolism": Disorders like Lesch-Nyhan Syndrome, Gout, and ADA deficiency.

Self- Study (18h):

1. Watch a short documentary or video lecture + timeline creation of key milestones in inborn errors of metabolism.
2. Hereditary Fructose Intolerance (HFI): Case study + symptom/pathway mapping.
3. Glycogen Storage Diseases (Von Gierke & Pompe): Compare GSD types in a chart: enzyme, tissue affected, symptoms, treatment.
4. Lysosomal Storage Diseases (e.g., Tay-Sachs, Niemann-Pick): Enzyme deficiency, substrate accumulation. Watch animation + draw lysosomal degradation pathway.
5. Defects in Amino Acid Metabolism: diet planning for a PKU patient. Match enzyme → pathway → disease.

MODULE IV: Clinical Biochemistry 12h[9L+3T]

Clinical Biochemistry: Significance of Body fluids (blood and urine) to **diagnose, monitor and manage** diseases – A general introduction. Complete Blood Count (CBC), Electrolyte Panel, Liver Function Tests (LFTs), Renal Function Tests (RFTs), Thyroid Function Tests, Pancreatic Enzymes. Marker molecules and Tumor Markers - PSA (prostate), AFP (liver), CA-125 (ovary), CEA (colon). Inflammatory Markers. Isoenzymes and biomarkers in myocardial infarction.

Tutorial:

Interpreting Routine Biochemical Panels: CBC, LFT, RFT & Electrolytes". Small group interpretation of sample lab reports; Explain the physiological basis and interpretation of thyroid function tests (T3, T4, TSH): Case scenarios: Hyperthyroidism vs hypothyroidism; Group discussion on the ethical use of tumor markers in asymptomatic individuals. Case-based interpretation: chest pain with elevated troponin vs non-cardiac causes.

Self-Study (18h):

1. Watch an introductory video on clinical biochemistry. Create a concept map: types of body fluids, their common tests, and diagnostic roles.
2. Electrolyte Panel Basics. Diagram electrolyte regulation + a mini quiz on hypo/hyper-natremia/kalemia.
3. Interpret two sample reports (hepatitis vs obstructive jaundice). ase-based analysis: chronic kidney disease vs acute kidney injury.
4. Key Tumor Markers: Application of Tumor Markers. Read short case studies and decide if tumor markers are useful for diagnosis or monitoring.
5. Integrated Clinical Biochemistry Review: Practice full lab report analysis for 2–3 simulated cases (e.g., thyroid disorder, kidney disease, cancer monitoring). Reflective writing: "How understanding lab values helps in clinical decision-making."
6. Rapid Biochemical Diagnostics Using Point-of-Care Technologies.

Textbooks

1. A. L. Lehninger, D. L. Nelson, and M. M. Cox, *Lehninger Principles of Biochemistry*, 5th ed., Macmillan, 2005.
2. J. M. Berg, G. J. Gatto Jr., J. Hines, J. L. Tymoczko, and L. Stryer, *Biochemistry*, 9th ed., Macmillan Higher Education, 2023.
3. D. M. Vasudevan, S. Sreekumari, and K. Vaidyanathan, *Textbook of Biochemistry for Medical Students*, 7th ed., JP Medical Ltd., 2013.

Reference books

1. J. M. Walker and K. Wilson (Eds.), *Principles and Techniques of Biochemistry and Molecular Biology*, 7th ed., Cambridge University Press, 2010.
2. D. Voet and J. G. Voet, *Biochemistry: International Adaptation*, 5th ed., John Wiley & Sons,2021.
3. K. N. Frayn, *Metabolic Regulation: A Human Perspective*, 3rd ed., John Wiley & Sons, 2013.
4. N. M. Rao, *Medical Biochemistry*, 4th ed., New Age International, 2006.

5. M. L. Bishop, *Clinical Chemistry: Principles, Techniques, and Correlations*, 8th ed., Jones & Bartlett Learning, 2020.
6. M. Murphy, R. Srivastava, and K. Deans, *Clinical Biochemistry – An Illustrated Colour Text*, 6th ed., Elsevier Health Sciences, 2023.

NPTEL/SWAYAM Courses for reference:

1. S. Dasgupta, "Biochemistry," NPTEL, IIT Kharagpur, 2020. [Online]. Available: https://nptel.ac.in/courses/102/103/102103015/
2. S. Ganesh, "Overview and Integration of Cellular Metabolism," NPTEL, IIT Kanpur, 2020. [Online]. Available: https://nptel.ac.in/courses/102/104/102104064/

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48 hours]
	MODULE 1 [12 hours]	
1.1	Introduction to biochemistry: scope, relevance to biotechnology - Chemical foundations: pH, buffers, water as a biological solvent. Biomolecules: classification, structure, and function.	2
1.2	Glycosidic bonds, peptide bonds, and phosphodiester bonds. Glycosaminoglycans (hyaluronic acid, Heparan Sulphate, and Keratan Sulphate) and their significance.	1
1.3	Lipids: Membrane lipids, Cholesterol, Prostaglandins and Leukotrienes (functions only).	1
1.4	Proteins: Levels of protein organization. Significance (only) of Ramachandran's plot.	2
1.5	Functional proteins: Basic structure of haemoglobin, collagen, and insulin.	1
1.6	Blood group substances.	1
1.7	Nucleic acids: DNA and RNA structure and types.	1
	Tutorial	3
	MODULE II [14 hours]	
2.1	ATP - the energy currency. Carbohydrate Metabolism: Glycolysis, Substrate level phosphorylation, gluconeogenesis and Cori cycle, regulation. Citric Acid Cycle: energy yield, regulation.	3
2.2	Electron Transport Chain, oxidative phosphorylation, mitochondrial diseases. Pentose Phosphate Pathway and oxidative stress.	3
2.3	Lipid Metabolism: β-oxidation of fatty acids, ketone bodies.	2
2.4	Protein Metabolism: Transamination, deamination, urea cycle.	1
2.5	Nucleotide Metabolism: Biosynthesis and degradation of purines and pyrimidines (only salvage pathway).	2
	Tutorial	3
	MODULE III [10 hours]	

3.1	Definition and historical perspective. Defects in carbohydrate metabolism: Diabetes, Lactose Intolerance, **Hereditary Fructose Intolerance**, Glycogen storage diseases (Von Gierke Disease & Pompe Disease).	2
3.2	Defects in lipid metabolism: hypercholesterolemia, Hypo and Hyper lipoproteinemia, Lysosomal Storage Disorders.	2
3.3	Defects in amino acid metabolism: Phenylketonuria, Tyrosinosis, Albinism, Alkaptonuria, Maple syrup urine disease, Hartnup disease.	1
3.4	Defects in nucleotide metabolism: Lesch-Nyhan Syndrome, Gout, Adenosine Deaminase (ADA) Deficiency.	2
	Tutorial	3
MODULE IV [12 hours]		
4.1	Significance of Body fluids (blood and urine) to diagnose, monitor and manage diseases – A general introduction.	2
4.2	Complete Blood Count (CBC).	1
4.3	Electrolyte Panel, Liver Function Tests (LFTs), Renal Function Tests (RFTs), Thyroid Function Tests, Pancreatic Enzymes.	2
4.4	Marker molecules and Tumor Markers - PSA (prostate), AFP (liver), CA-125 (ovary), CEA (colon).	2
4.5	Inflammatory Markers. Isoenzymes and biomarkers in myocardial infarction.	2
	Tutorial	3
CO Assessment Questions		
CO-1	**3 Mark Questions** 1. Explain the role of glycosidic, peptide, and phosphodiester bonds in the formation of biomolecules. **(Understand)** 2. State the functions of prostaglandins, leukotrienes, and cholesterol in biological systems. **(Understand)** 3. What is the relevance of pH and buffers in maintaining physiological homeostasis? **(Analyze)** 4. Differentiate between the structures and functions of membrane lipids and functional proteins such as hemoglobin and insulin. **(Analyze)** **9 Mark Questions** 1. Explain the scope of biochemistry and its relevance to modern biotechnology with suitable examples. **(Understand)** 2. Describe the structure, classification, and biological functions of carbohydrates. Add a note on glycosaminoglycans and their physiological significance. **(Understand & Apply)** 3. Compare and contrast the structures and types of DNA and RNA. How do these structures relate to their respective functions? **(Understand)**	

	4. Discuss the basic structure and functional significance of haemoglobin, collagen, and insulin. How do these proteins contribute to human physiology? **(Understand & Apply)**
CO-2	**3 Mark Questions** 1. Illustrate the steps of glycolysis and identify the points of regulation in the pathway. **(Apply)** 2. What are ketone bodies? Under what physiological conditions are they produced and utilized? **(Understand & Apply)** 3. Define transamination and deamination. How are these reactions essential in amino acid catabolism? **(Understand & Analyze)** 4. What is the impact of mitochondrial dysfunction on oxidative phosphorylation and its relation to metabolic diseases? **(Apply)** **9 Mark Questions** 1. Describe the glycolytic pathway and explain how it is regulated. Add a note on the Cori cycle and its physiological relevance. **(Understand & Analyze)** 2. Explain the Citric Acid Cycle with energy yield per acetyl-CoA. How is the cycle regulated at key steps? **(Understand)** 3. Discuss the components and mechanisms of the electron transport chain and oxidative phosphorylation. How do defects in this pathway lead to mitochondrial diseases? **(Understand & Analyze)** 4. Outline the salvage pathways for purine and pyrimidine metabolism. Why are these pathways important for nucleotide homeostasis in certain tissues? **(Understand & Analyze)**
CO-3	**3 Mark Questions** 1. Define inborn errors of metabolism and mention one historical milestone in their discovery. **(Remember and Understand)** 2. Differentiate between hypercholesterolemia and hypolipoproteinemia with one cause for each. **(Remember and Understand)** 3. Analyze the metabolic defect in Phenylketonuria and explain how it leads to clinical symptoms. **(Analyze)** 4. Given a patient case with symptoms of hypoglycemia and hepatomegaly, identify the most probable glycogen storage disorder and justify your choice. **(Apply)** **9 Mark Questions** 1. Explain the biochemical defects, symptoms, and clinical significance of Von Gierke Disease and Pompe Disease. **(Remember and Understand)**

	2. Describe the causes, metabolic consequences, and diagnosis of Phenylketonuria, Tyrosinosis, and Maple Syrup Urine Disease. **(Remember and Understand)** 3. Discuss Hereditary Fructose Intolerance and Lactose Intolerance, highlighting the enzymes involved and associated clinical manifestations. **(Analyze)** 4. Explain the metabolic basis and symptoms of Lesch-Nyhan Syndrome and Gout. Why are these conditions classified as defects in nucleotide metabolism? **(Analyze)**
CO-4	**3 Mark Questions** 1. Name any three parameters included in a Complete Blood Count (CBC) and mention their diagnostic relevance. **(Understand)** 2. What is the role of C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR) as inflammatory markers? **(Understand & Analyze)** 3. Describe the significance of Liver Function Tests (LFTs) and how they assist in diagnosing liver disorders. **(Understand)** 4. Assess the diagnostic value of tumor markers such as PSA and CA-125 in the early detection of cancer. **(Evaluate)** **9 Mark Question** 1. Describe the components and diagnostic significance of Liver Function Tests (LFTs) and Renal Function Tests (RFTs). **(Understand & Analyze)** 2. Explain the role of tumor markers in cancer diagnosis and monitoring, with reference to PSA, AFP, CA-125, and CEA. **(Understand & Analyze)** 3. Discuss the Thyroid Function Tests in detail. How do alterations in TSH, T3, and T4 levels aid in diagnosing thyroid disorders? **(Understand & Analyze)** 4. Outline the major cardiac biomarkers and isoenzymes used in diagnosing myocardial infarction. Explain their time-course and diagnostic importance. **(Understand & Analyze)**
Prepared by: Dr. Ambili Mechoor, Professor, Department of Biotechnology Reviewed by: Dr. Anilkumar , Scientist G, Biomedical Technology Wing, SCTIMST	

24BTT303	MICROBIOLOGY	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:
This course introduces the fundamentals of microbiology, covering microbial diversity, cell structure, and key techniques such as microscopy and staining. It explores microbial nutrition, growth, and control, along with their roles in environmental processes, food safety, and industrial applications. The course emphasizes the significance of microorganisms in health, sustainability, and biotechnology.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Apply the knowledge on ultra-structural features of microorganisms, visualization and classification techniques to understand the diversity of microorganisms. **[Apply]**
CO 2	Evaluate and apply appropriate methods to cultivate, enumerate and control microorganisms. **[Apply]**
CO 3	Apply microbiological knowledge to design eco-friendly solutions and illustrate the essential roles of microbes in environmental processes. **[Apply]**
CO 4	Analyze the functional roles of microorganisms in industrial processes and evaluate their impact on human well-being. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	3			2					
CO2	2	2	3		3	2					
CO3	3	3	3			3					
CO4	3	3	3			3					

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze			√	
Evaluate			√	
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Lecture [L]				
	Attendance	Assignment	Test-1	Test-2	Total Marks

3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 1	8 Questions (2 Questions from each module), each question carries 3 marks. Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Fundamentals of Microbiology and Microbial Diversity 12h[9L + 3T]

History and scope of microbiology: Overview of key milestones in microbiology, contributions of pioneers, and the role of microbiology in medicine, industry, and environment.

Classification and nomenclature of microorganisms: Introduction to taxonomy, binomial nomenclature, major microbial groups, and systems of classification.

Microbial Diversity:

Bacteria: characteristics and classification; Archea: unique features and habitats; Fungi: yeasts, molds, and their significance; Protozoa and algae: characteristics and environmental roles; Viruses: structure, replication, and classification.

Tutorial:

Recent advances in microbial Biotechnology, Classification of microbes using standard taxonomy databases, Role of algae in bioremediation.

Self-Study (18h):

1. Impact of microbiome research on human health – Review microbiome-related case studies.
2. Global burden of microbial diseases – A WHO perspective. Analyze WHO fact sheets.
3. Recent advances in microbial taxonomy using genomic tools – 16SrDNA sequencing.
4. Case study: Eradication of smallpox through viral biology understanding. Analyze historical data and present it as a timeline.
5. Current status of antimicrobial resistance (AMR) - Watch short WHO videos and propose awareness campaign ideas.

6. Pathogen Profiling: Identification Methods in Clinical Microbiology.

MODULE II: Microbial Cell Structure, Microscopy, and Staining Techniques 12h[9L + 3T]

Overview of prokaryotic and eukaryotic cell structures: Comparison of structural features such as cell walls, membranes, organelles, ribosomes, and genetic material **Principles of Microscopy**: Working principles of light, electron (TEM, SEM), and fluorescence microscopes.
Staining Techniques: Simple staining, Differential staining, Special staining: Endospore, capsule, and flagella stains to visualize specific.
Tutorial:
Comparison of prokaryotic and eukaryotic cell structures, Applications and limitations of different microscopy techniques, Interpretation of microscopic images of staining.

Self-Study (18h):

1. Antibiotics targeting cell wall synthesis.
2. Capsules and pathogenicity – case study.
3. Virtual microscopy exploration and interpretation.
4. Historical evolution of microscopy tools- Design a timeline with images.
5. Microscopy and staining in clinical diagnosis.

MODULE III: Microbial Nutrition, Growth, Cultivation, and Control 12h[9L + 3T]

Nutritional Requirements and Types of Microorganisms: Nutritional classification; essential nutrients and growth factors.
Microbial Growth: Growth Curve, Measurement of growth and growth yields and effect of environmental factors on growth
Cultivation Techniques: Media types and pure culture methods (streak, pour, spread plates).
Control of Microorganisms: Physical and chemical methods of controlling microbial growth and sterilization.
Tutorial:
Microbial growth curve analysis and Interpretation, Designing growth media for different microbes, Sterilization and disinfection strategies.

Self- Study (18h):

1. Home-based yogurt-making as a microbial growth model- Document and analyze the growth using basic tools.
2. Sterilization protocols in hospitals and space missions - Develop a checklist or SOP comparison.
3. Quality control in Biopharmaceutical manufacturing.
4. Effect of environmental stresses on microbial growth.

MODULE IV: Environmental, Food, and Industrial Microbiology 12h[9L + 3T]

Roles in Nutrient Cycling: Contribution of microbes to the carbon, nitrogen, and sulfur cycles
Microbiological Analysis of water: Sanitary tests for Coliforms (MPN, IMViC and Defined Substrate Test)
Microbial Communities: Structure and function of biofilms, quorum sensing mechanisms

Food Microbiology: Role of microbes in food spoilage and contamination, food borne diseases and intoxications, food preservation methods and beneficial microbes in food production.
Industrial Microbiology: Commercially important microbes for industrial fermentation.
Tutorial:
Role of nitrogen cycle in agriculture, Interpretation of results of microbiological analysis of water, Microbial enzymes in textile and paper industries.

Self-Study (18h):

1. Microbial diversity in traditional fermented foods*:* Survey and document local fermentation practices.
2. Water and Food microbiology – Case study explorations.
3. Fermentation techniques in indigenous food products.
4. Role of industrial microbes in sustainable production.

Textbooks

1. J. M. Willey, L. M. Sherwood, and C. J. Woolverton, *Prescott's Microbiology*, 11th ed., McGraw-Hill Education, 2020.
2. G. J. Tortora, B. R. Funke, and C. J. Case, *Microbiology: An Introduction*, 13th ed., Pearson Education, 2018.
3. M. J. Pelczar, E. C. S. Chan, and N. R. Krieg, *Microbiology*, 5th ed., Tata McGraw-Hill, 2001.

Reference books

1. M. T. Madigan, K. S. Bender, D. H. Buckley, W. M. Sattley, and D. A. Stahl, *Brock Biology of Microorganisms*, 16th ed., Pearson, 2020.
2. R. C. Dubey and D. K. Maheshwari, *A Textbook of Microbiology*, 5th ed., S. Chand Publishing, 2023.

NPEL/SWAYAM Courses for reference:

1. Dasgupta, "Microbiology," NPTEL, IIT Kharagpur. [Online]. Available: https://archive.nptel.ac.in/courses/102/103/102103015/
2. "Microbial Biotechnology," NPTEL. [Online]. Available: https://onlinecourses.nptel.ac.in/noc25_bt33/preview
3. "Applied Environmental Biotechnology," NPTEL. [Online]. Available: https://onlinecourses.nptel.ac.in/noc21_ce07/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48 hours]
	MODULE 1 [12 hours]	
1.1	Overview of key milestones in microbiology, contributions of pioneers	2
1.2	The role of microbiology in medicine, industry, and environment	1
1.3	Introduction to taxonomy, binomial nomenclature, major microbial groups, and systems of classification	2
1.4	Bacteria: characteristics and classification; Archaea: unique features and habitats	2

1.5	Fungi: yeasts, molds, and their significance	1
1.6	Protozoa and algae: characteristics and environmental roles	2
1.7	Viruses: structure, replication, and classification;	2
MODULE II [12 hours]		
2.1	Comparison of structural features such as cell walls, membranes,	1
2.2	Comparison of structural features such as organelles, ribosomes, and genetic material	3
2.3	Working principles of light microscopes	3
2.4	Electron (TEM, SEM) microscopes	2
2.5	Fluorescence microscope	1
2.6	Simple staining, Differential staining	1
2.7	Special staining: Endospore, capsule, and flagella stains to visualize specific structures.	1
MODULE III [12 hours]		
3.1	Nutritional classification; essential nutrients and growth factors.	2
3.2	Growth Curve	1
3.3	Measurement of growth and growth yields	2
3.4	Effect of environmental factors on growth	1
3.5	Media types	2
3.6	Pure culture methods (streak, pour, spread plates)	1
3.7	Physical and chemical methods of controlling microbial growth and sterilization.	3
MODULE IV [12 hours]		
4.1	Contribution of microbes to the carbon, nitrogen, and sulfur cycles	2
4.2	Sanitary tests for Coliforms (MPN, IMViC and Defined Substrate Test)	2
4.3	Structure and function of biofilms, quorum sensing mechanisms	2
4.4	Role of microbes in food spoilage and contamination, food borne diseases and intoxications	2
4.5	Food preservation methods and beneficial microbes in food production.	2
4.6	Commercially important microbes for industrial fermentation.	2

CO Assessment Questions	
CO-1	1. Using the binomial nomenclature system, classify and name a given set of microorganisms and explain the basis of their classification. **(Analyze)** 2. Apply knowledge of microbial cell wall structure to explain the Gram staining outcome of Gram-positive and Gram-negative bacteria.**(Apply)** 3. Select appropriate microscopy techniques (light, SEM, TEM, fluorescence) to visualize specific microbial structures and justify your choice. **(Apply)**
	1. Design a cultivation protocol to isolate a pure culture from a mixed microbial sample using streak and pour plate methods. **(Apply)**

CO-2	2. Explain how physical and chemical agents are selected for sterilizing different types of laboratory media and instruments. **(Apply)** 3. Analyze the effects of temperature and pH on the growth curve of a bacterial species using experimental data. **(Analyze)**
CO-3	1. Propose a microbial strategy to improve soil fertility through nitrogen and sulfur cycling. **(Apply)** 2. Design a method to assess the microbial quality of drinking water using MPN and IMViC tests. **(Apply)** 3. Illustrate how quorum sensing contributes to the formation of biofilms and their ecological significance. **(Understand)**
CO-4	1. Examine the industrial use of *Saccharomyces cerevisiae* in alcohol production and its economic relevance. **(Analyze)** 2. Compare the roles of different microbes in food fermentation and preservation processes. **(Apply)** 3. Analyze the public health implications of microbial contamination in food and suggest control measures. **(Analyze)**
Prepared by: Dr. Dhanya Gangadharan, Associate Professor, Department of Biotechnology Reviewed by: Dr. Anilkumar , Scientist G, Biomedical Technology Wing, SCTIMST	

24BTR 304	INDUSTRIAL BIOPROCESS TECHNOLOGY	L	T	P	R	C	Year of Introduction
		3	0	0	1	4	2024

Preamble:
Industrial bioprocess technology plays a vital role in translating biological innovations into commercially viable processes for the production of pharmaceuticals, biofuels, food, and other bio products. This course provides an in-depth understanding of the principles, techniques, and applications of bioprocess engineering, with a focus on microbial and enzyme-based production systems. Students will explore fundamental concepts such as fermentation technology, bioreactor design and downstream processing, ensuring a comprehensive grasp of industrial-scale biological manufacturing.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Explain the scope and significance of industrial bioprocessing, types of production cell systems and metabolites. **[Understand]**
CO 2	Analyze fundamental principles of fermentation technology to design and optimize media composition, develop inoculum strategies, monitor key process parameters, and analyze recent bioreactor technologies for enhanced bioprocess performance. **[Analyze]**
CO 3	Evaluate various stages in downstream processing for the recovery and purification of fermented products. **[Evaluate]**
CO 4	Analyze industrial bioprocesses for the production of various metabolites, recombinant proteins and microbial products used in agriculture and food, with an emphasis on production methods and the role of key bioprocessing industries in India. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3		2							
CO2	2	3	3	3	2						
CO3	3	2	3	3							2
CO4	3	2	3	3		2			3	3	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√

Apply	√	√	√	√
Analyze			√	
Evaluate			√	
Create				

Assessment Pattern for Project Component

Bloom's Category	**Continuous Assessment Tools**		
	Evaluation 1	**Evaluation 2**	**Report**
Remember			
Understand			
Apply			
Analyze	√	√	√
Evaluate	√	√	√
Create	√	√	√

Mark Distribution of CIA

Course Structure [L-T-P-R]	**Lecture [L]**							
	Attendance	**Assignment**	**Test-1**	**Test-2**	**Evaluation 1**	**Evaluation 2**	**Report**	**Total Marks**
3-0-0-1	5	5	7.5	7.5	10	10	5	50

Total Mark distribution

Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hours

End Semester Examination [ESE]: Pattern

PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 2	2 Questions from each module. Any full 6 Questions, each carrying 3 marks (6x3=18 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub-divisions. Each question carries 8 marks. Marks: (4x8 = 32 marks)	50

SYLLABUS

MODULE I: Introduction to Industrial Bioprocesses [9h]

Overview of Industrial Bioprocessing: Scope and significance in pharmaceuticals, food, agriculture, and environment, Types of bioproducts: antibiotics, organic acids, enzymes, amino acids, vaccines, and biofuels.

Types of Production Cell Systems: Microbial cell factories**:** Bacteria (e.g., *E. coli*), yeast (*S. cerevisiae*), fungi (*Aspergillus*, *Penicillium*), Mammalian cell lines**:** Introduction to CHO (Chinese Hamster Ovary), HEK, BHK cells and their role in therapeutic protein production. Differences in microbial vs mammalian systems (growth, complexity, post-translational modifications)

Cell Product Categories: Primary vs Secondary Metabolites: Recombinant proteins, monoclonal antibodies (mAbs), and viral vaccines.

Self-Study (16h):

1. Virtual tour of an industrial bioreactor facility. (via YouTube or virtual lab platforms)
2. Culture collection centers and its function.
3. Explore the role of mammalian cells in vaccine development. (e.g., COVID-19 vaccine platforms)

MODULE II: Media, Inoculum, and Fermentation Workflows [9h]

Media Formulation and Optimization: Nutritional requirements: Carbon, nitrogen, trace elements, vitamins, Role of precursors, inducers, and antifoams, Media types: Defined vs complex, Optimization approaches: One-factor-at-a-time (OFAT), statistical tools (introduction only)

Sterility and Controlled Environments: Importance of sterility in fermentation, Sterilization of media and fermenter.Role of cleanrooms and biosafety levels

Screening and Selection of Production Strains: Primary Screening, Secondary Screening

Strain Improvement Techniques: Mutation and Selection: UV, chemical mutagenesis, Recombinant DNA Approaches.

Inoculum Development and Scale-Up: Sequential stages of inoculum development, Inoculum age, size, and physiological state.

Types of Fermentation (Conceptual Overview): Batch, Fed-Batch Fermentation, Continuous Fermentation- Advantages, disadvantages, and typical applications.

Fermentation Monitoring Parameters: Key Parameters: Dissolved oxygen (DO), pH, Temperature, Foam; Sensors and probes: basic functions; Impact of parameter deviations on product yield and quality.

Recent Advancements in Bioreactor Technology: Single-Use Bioreactors (SUBs): Disposable systems, rapid setup, reduced cleaning; Miniaturized Bioreactors: Small-scale parallel fermentation, scale-down models.

Self-Study (16h):

1. Relevance of advanced bioreactor technology in personalized medicine and research-scale production.
2. Case study: Inoculum development for vaccine production.
3. Types of fermentation in food processing industries.
4. Basic biosafety and good laboratory practices in industrial biotech.

MODULE III: Bioproduct Recovery and Downstream Operations [9h]

Importance of Downstream Processing: Role of DSP in product recovery and cost, Impact on product quality, yield, and regulatory compliance, DSP contribution to overall bioprocess economics

Stages of Downstream Processing:

Primary Recovery Steps: Cell Separation Techniques – Centrifugation, Filtration Product Release (for Intracellular Products): Cell Disruption Methods - Mechanical Methods, Chemical Methods. Product Concentration: Concentration Techniques – Evaporation, Crystallization. Purification and Polishing: Introduction to Chromatography - Basic Principles: Adsorption, partitioning, ion exchange Column chromatography overview - Types (Brief Introduction) Product Finishing: Final Formulation and Packaging.

Self- Study (19h):

1. Simple flowchart of DSP for an enzyme or organic acid.
2. Introduction to characterization methods of an unknown protein.
3. Green downstream technologies.
4. Automation in fermentation processes.

MODULE IV: Applications and Industrial Case Studies [9h]

Industrial Production Case Studies: Enzymes (Amylase & Protease Production), Organic Acids (Citric Acid & Lactic Acid), Biofuels and Bioenergy, Recombinant Proteins (Insulin and Vaccine production) Bioprocessing Applications: Agricultural Biotechnology (Biofertilizers & Biopesticides) - Microbial agents, Production, Regulatory and safety aspects

Food Biotechnology: Fermented Foods & Single-Cell Protein (SCP) - Microbial sources, Cultivation, harvesting, and drying and applications

Overview of Bioprocessing Industries in India: Major players (e.g., Biocon, Serum Institute, Novozymes India), Key sectors: Biopharma, industrial enzymes, bioenergy.

Self-Study (21h):

1. Legal and ethical concerns in the use of GMOs in food bioproducts.
2. Case study: Production of a probiotic drink
3. Role of biotech in the circular bioeconomy.
4. Industrial visit report or company profile review.
5. Bioprocess patents or innovation trends in India.

Textbooks

1. M. L. Shuler and F. Kargi, *Bioprocess Engineering: Basic Concepts*, 2nd ed., Prentice Hall, 2015.
2. U. Satyanarayana, *Biochemistry*, 5th ed., Elsevier Health Sciences, 2013.
3. C. F. Bryce and D. Balasubramanian, *Concepts in Biotechnology*, 2nd ed., Universities Press, 2004
4. C. Ratledge and B. Kristiansen, *Basic Biotechnology*, 2nd ed., Cambridge University Press, 2001.

5. P. M. Doran, *Bioprocess Engineering Principles*, 2nd ed., Elsevier, 1995.

Reference books

1. L. E. Casida, *Industrial Microbiology*, New Age International, 1st ed., 1968.
2. W. Crueger, A. Crueger, T. D. Brock, and T. D. Brock, *Biotechnology: A Textbook of Industrial Microbiology*, 1st ed., Sinaeur Associates, 1990.
3. M. Moo-Young (Ed.), *Comprehensive Biotechnology*, 3rd ed., Elsevier, 2019.
4. P. F. Stanbury, A. Whitaker, and S. J. Hall, *Principles of Fermentation Technology*, 2nd ed., Butterworth-Heinemann, 1995.
5. E. M. T. El-Mansi, C. F. A. Bryce, and B. S. Hartley, "Fermentation biotechnology: An historical perspective," in *Fermentation Microbiology and Biotechnology*, 4th ed., Taylor & Francis, 1999.

NPTEL/SWAYAM Courses for reference:

1. "Industrial Biotechnology," NPTEL. [Online]. Available: https://archive.nptel.ac.in/courses/102/105/102105058/
2. "Principles of Downstream Techniques in Bioprocess," NPTEL. [Online]. Available: https://archive.nptel.ac.in/courses/102/106/102106022/

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	**Overview of Industrial Bioprocessing:** Scope and significance in pharmaceuticals, food, agriculture, and environment.	1
1.2	Types of bioproducts: antibiotics, organic acids, enzymes, amino acids, vaccines, and biofuels.	1
1.3	**Types of Production Cell Systems:** Microbial cell factories**:** Bacteria (e.g., *E. coli*), yeast (*S. cerevisiae*), fungi (*Aspergillus*, *Penicillium*)	2
1.4	Mammalian cell lines**:** Introduction to CHO (Chinese Hamster Ovary), HEK, BHK cells and their role in therapeutic protein production	2
1.5	Differences in microbial vs mammalian systems (growth, complexity, post-translational modifications)	1
1.6	**Categories: Primary vs Secondary Metabolites:** Recombinant proteins, monoclonal antibodies (mAbs), and viral vaccines	2
	MODULE II [9 hours]	
2.1	**Media Formulation and Optimization:** Nutritional requirements: Carbon, nitrogen, trace elements, vitamins, Role of precursors, inducers, and antifoams.	1
2.2	Media types: Defined vs complex, Optimization approaches: One-factor-at-a-time (OFAT), statistical tools (introduction only)	1

2.3	**Sterility and Controlled Environments:** Importance of sterility in fermentation, Sterilization of media and fermenter. Role of cleanrooms and biosafety levels.	1
2.4	**Screening and Selection of Production Strains:** Primary Screening, Secondary Screening.	1
2.5	**Strain Improvement Techniques:** Mutation and Selection: UV, chemical mutagenesis, Recombinant DNA Approaches.	1
2.6	**Inoculum Development and Scale-Up:** Sequential stages of inoculum development, Inoculum age, size, and physiological state.	1
2.7	**Types of Fermentation (Conceptual Overview):** Batch, Fed-Batch Fermentation, Continuous Fermentation- Advantages, disadvantages, and typical applications.	1
2.8	**Fermentation Monitoring Parameters:** Key Parameters: Dissolved oxygen (DO), pH, Temperature, Foam; Sensors and probes: basic functions; Impact of parameter deviations on product yield and quality.	1
2.9	**Recent Advancements in Bioreactor Technology:** Single-Use Bioreactors (SUBs):Disposable systems, rapid setup, reduced cleaning; Miniaturized Bioreactors: Small-scale parallel fermentation, scale-down models.	1
MODULE III [9 hours]		
3.1	**Importance of Downstream Processing:** Role of DSP in product recovery and cost, Impact on product quality, yield, and regulatory compliance, DSP contribution to overall bioprocess economics.	1
3.2	Primary Recovery Steps: Cell Separation Techniques – Centrifugation, Filtration.	1
3.3	Product Release (for Intracellular Products): Cell Disruption Methods - Mechanical Methods, Chemical Methods.	1
3.4	Product Concentration: Concentration Techniques – Evaporation, Crystallization	1
3.5	Purification and Polishing: Introduction to Chromatography	1
3.6	Basic Principles: Adsorption, partitioning, ion exchange Column chromatography overview - Types (Brief Introduction)	2
3.7	Product Finishing: Final Formulation and Packaging	2
MODULE IV [9 hours]		
4.1	Industrial Production Case Studies: Enzymes (Amylase & Protease Production)	1
4.2	Organic Acids (Citric Acid & Lactic Acid)	1
4.3	Biofuels and Bioenergy	1
4.4	Recombinant Proteins (Insulin and Vaccine production)	1

4.5	Bioprocessing Applications: Agricultural Biotechnology (Biofertilizers & Biopesticides)	1
4.6	Microbial agents, Production, Regulatory and safety aspects	1
4.7	Food Biotechnology: Fermented Foods & Single-Cell Protein (SCP) - Microbial sources, Cultivation, harvesting, and drying and applications	1
4.8	Overview of Bioprocessing Industries in India: Major players (e.g., Biocon, Serum Institute, Novozymes India)	1
4.9	Key sectors: Biopharma, industrial enzymes, bioenergy	1

PROJECT

In line with the rapidly evolving demands of biotechnology industries and the increasing emphasis on innovation and applied learning, this project-based learning (PBL) initiative is designed to bridge the gap between theoretical knowledge and real-world industrial processes. Through hands-on project work, students will explore various stages of a bioprocess—ranging from upstream development and inoculum preparation to downstream recovery and product formulation. Students will enhance their ability to critically evaluate and select appropriate methods for producing bioproducts such as enzymes and organic acids while addressing economic, environmental, and safety considerations.

LESSON PLAN FOR PROJECT COMPONENT

No.	TOPIC	No. of Hours (12)
1	Preliminary Design of the Project	2
2	Zeroth presentation (4th week)	2
3	Project Work - First Phase	2
4	Interim Presentation	2
5	Project work - Final Phase & Report writing (discussions in class during project hours)	2
6	Final Evaluation, Presentation and Exhibition(11th and12th weeks)	2

CO Assessment Questions

CO-1	**3 mark Questions** 1. Define primary and secondary metabolites. **(Understand)** 2. List the various microbial production cell systems **(Understand)** 3. Explain the differences between microbial and mammalian production systems. **(Understand)** 4. What are monoclonal antibodies? **(Understand)** **8 mark Questions** 1. Explain the significance of industrial bioprocessing in pharmaceutical production and how it contributes to the global healthcare industry? **(Apply)** 2. Describe the main differences between primary and secondary metabolites in terms of their production and application in industry. **(Apply)**

	3. Describe how CHO cells are used in therapeutic protein production and why they are preferred for certain types of proteins. **(Analyze)** 4. Define recombinant proteins and monoclonal antibodies (mAbs), and explain their significance in modern biopharmaceutical production. **(Apply)**
CO-2	**3 mark Questions** 1. What are the different methods of isolating microorganisms for fermentation? **(Understand)** 2. State any three methods of sterilization used in upstream processing. **(Understand)** 3. Describe the components of industrial production media. **(Understand)** 4. Illustrate the selection methods employed for the strain improved organisms. **(Understand)** **8 mark Questions** 1. Examine the impact of different sterilization methods on the integrity of heat-sensitive media components during fermentation preparation **(Apply)** 2. Compare and contrast the effectiveness of primary and secondary screening methods in identifying high-yield production strains. **(Apply)** 3. Analyze the advantages and limitations of UV mutagenesis versus chemical mutagenesis for strain improvement in an industrial setting. **(Analyze)** 4. Analyze how the adoption of single-use bioreactors changes operational workflows and contamination risk compared to traditional stainless steel fermenters. **(Analyze)**
CO-3	**3 mark Questions** 1. List any four cell disruption techniques. **(Understand)** 2. Write note on ion exchange chromatography. **(Understand)** 3. Illustrate the role of crystallization in downstream processing. **(Apply)** 4. Explain the principle of affinity chromatography. **(Apply)** **8 mark Questions** 1. Justify the selection of a specific cell disruption method (mechanical or chemical) based on the nature of the intracellular product and process scale. **(Analyze)** 2. Compare and evaluate the use of different chromatography types (e.g., affinity, size exclusion, ion exchange) for polishing high-purity therapeutic proteins. **(Analyze)** 3. Which chromatography method is best for purifying monoclonal antibodies? Explain your reasoning. **(Analyze)**

	4. Briefly explain the principle and applications of column chromatography. **(Understand)**
CO-4	**3 mark Questions** 1. Illustrate the production of SCP. **(Understand)** 2. Give note on biocrontrol agents. **(Understand)** 3. With neatly labelled flow diagram explain the production of biofertilizers. **(Understand)** 4. Give an account on the major players in the bioproducts manufacturing sector. **(Understand)** **8 mark Questions** 1. Explain how biofertilizers contribute to sustainable agriculture. **(Apply)** 2. Apply the principles of bioprocessing to produce lactic acid on a small scale? **(Apply)** 3. Compare the industrial production process of amylase and protease in terms of substrate, fermentation conditions, and recovery. **(Analyze)** 4. Analyze the challenges involved in large-scale vaccine production in terms of upstream and downstream processes. **(Analyze)**
Prepared by: Dr. Ranimol G, Asst. Professor, Department of Biotechnology	

24EST306	APPLIED DATA SCIENCE & ARTIFICIAL INTELLIGENCE	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:
This course covers the fundamentals of data analysis, including essential concepts in statistics and linear algebra, which form the basis for working with real-world data. Students will learn how to clean, transform, and visualize data, as well as handle missing values and detect outliers. The course provides hands-on experience with Python programming and data science libraries such as Pandas, NumPy, and Matplotlib. Additionally, it introduces the basics of machine learning and explores how these techniques are applied in engineering and industrial contexts.

Prerequisite: Problem Solving and Algorithmic Thinking with Python (24ESR105)

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Apply advanced mathematical concepts such as matrix operations, singular values, and principal component analysis to analyze and solve engineering problems. **[Apply]**
CO 2	Interpret data using statistical methods including descriptive statistics, correlation, and regression analysis to derive meaningful insights and make informed decisions. **[Apply]**
CO 3	Carry out exploratory data analysis (EDA), including data collection, cleaning, visualization, and statistical summarization. **[Apply]**
CO 4	Demonstrate foundational knowledge of machine learning paradigms and apply selected algorithms for classification and regression problems using Python. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3	2						
CO2	3	3	3	3	3						2
CO3	2	3	3	3	3				2		
CO4	3	3	2	3	3			2			2

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze		√	√	√
Evaluate				
Create				

Assessment Pattern for the Lab Component

Bloom's Category	Continuous Assessment Tools	
	Class work	**Test1**
Remember	√	√
Understand	√	√
Apply	√	√
Analyze	√	√
Evaluate		
Create		

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]				
	Attendance	**Assignment**	**Test-1**	**Test-2**	**Total Marks**
3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Linear Algebra for Data Science and AI [11h]

Role of Linear Algebra in Data Representation and Analysis, Introduction to vectors: properties, vector addition and subtraction, scalar multiplication. Vector norms and distance metrics.

Interpretation and computation. Matrix Decomposition- Singular Value Decomposition (SVD): concept and applications. Dimensionality Reduction, Principal Component Analysis.

Tutorial Questions:

Vector addition, subtraction and scalar multiplication, Singular Value Decomposition

Self-Study(18h):

1. Principal Component Analysis (PCA) using Eigenvectors
2. Orthogonality and Orthogonal Vectors
3. Matrix Rank and Its Significance
4. Vector and Matrix Broadcasting in NumPy.

MODULE II: Applied Probability and Statistics for AI and Data Science [11h]

Basics of probability-random variables and statistical measures - rules in probability- Bayes theorem and its applications- statistical estimation Maximum Likelihood Estimator (MLE) - statistical summaries Correlation analysis- linear correlation - regression analysis- linear regression (using least square method)

Types of Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics, Prescriptive Analytics, Big Data Analytics, Web Analytics, Social Media Analytics, Business Intelligence.

Tutorial Questions:

Problems on Probability, Measures of Dispersion, Covariance and Correlation, Linear Regression.

Self-Study(18h):

1. Difference between Classical and Empirical Probability.
2. Understanding Conditional Probability with Real-Life Applications.
3. Bayes' Theorem and Its Applications in Decision Making.
4. Real world case study on Social Media Analytics.
5. Application of Business Intelligence.

MODULE III: Exploratory Data Analysis (EDA) [14h]

Introduction to data analysis and the EDA process. Types of data: structured, unstructured, categorical, numerical. Data collection techniques and sources (CSV files, APIs, databases). Data cleaning: fixing rows and columns, handling missing data, standardizing values, treating invalid entries, removing duplicates. Univariate analysis: distribution of individual variables. Bivariate analysis: relationships between two variables. Data visualization: histograms, box plots, scatterplots, pair plots, heatmaps.

Tutorial Questions:

Data Cleaning, Bivariate Analysis, Boxplots

Self- Study(18h):

1. Feature engineering techniques.
2. Outlier detection and treatment methods.
3. Advanced data visualization with Plotly and Bokeh.

4. Time series data analysis basics, Introduction to big data tools for EDA (e.g., Apache Spark)
5. Introduction to clustering for exploratory analysis.
6. Data quality assessment metrics and frameworks.

MODULE IV: Machine Learning and Python for Data Science [12h]

Introduction to libraries: NumPy for numerical operations, Pandas for data manipulation, Matplotlib for visualization, SciPy for scientific computation. Introduction to machine learning: overview of supervised, unsupervised, and reinforcement learning. Key algorithms: regression, classification (logistic, Naïve Bayes), clustering (K-means). Model training and testing using scikit-learn. Evaluation metrics: accuracy, precision, recall, F1 score, confusion matrix. End-to-end implementation of a basic machine learning pipeline with real-world datasets.

Tutorial Questions:

K-Nearest Neighbors (KNN) algorithm, Classification Examples, Data Structure Applications.

Self-Study (18h):

1. Ensemble learning basics (Random Forest, Gradient Boosting)
2. Basics of neural networks and deep learning frameworks (TensorFlow, PyTorch)
3. Introduction to unsupervised learning beyond K-means (DBSCAN, hierarchical clustering)
4. Project Title: "Customer Segmentation and Purchase Prediction using Machine Learning"

Textbooks

1. J. VanderPlas, *Python Data Science Handbook: Essential Tools for Working with Data*, 1st ed. Sebastopol, CA, USA: O'Reilly Media, 2016.
2. P. Bruce and A. Bruce, *Practical Statistics for Data Scientists: 50 Essential Concepts*, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2017.

Reference books

1. M. X. Cohen, *Practical Linear Algebra for Data Science*, 1st ed. Sebastopol, CA, USA: O'Reilly Media, Inc., Sep. 2022.
2. J. Grus, *Data Science from Scratch*, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, Inc., Apr. 2015.
3. S. K. Mukhiya and U. Ahmed, *Hands-On Exploratory Data Analysis with Python*, 1st ed. Birmingham, UK: Packt Publishing, Mar. 2020.

NPTEL/SWAYAM Courses for reference:

1. Probability Theory for Data Science, Prof. Ishapathik Das, IIT Tirupati https://onlinecourses.nptel.ac.in/noc24_ma64/preview
2. Python for Data Science (Python-based), Prof. Ragunathan Rengasamy, IIT Madras, https://onlinecourses.nptel.ac.in/noc22_cs32/preview
3. Fundamentals of Artificial Intelligence, Prof. Shyamanta M. Hazarika, IIT Guwahati, https://onlinecourses.nptel.ac.in/noc24_ge47/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48 hours]
	MODULE 1 [11 hours]	
1.1	Role of Linear Algebra in Data Representation and Analysis,	1

1.2	Introduction to vectors: properties, vector addition and subtraction, scalar multiplication.	2
1.3	Vector norms and distance metrics.	2
1.4	Interpretation and computation.	1
1.5	Matrix Decomposition- Singular Value Decomposition (SVD): concept and applications.	1
1.6	Singular Value Decomposition (SVD): concept and applications.	1
1.7	Dimensionality Reduction,	2
1.8	Principal Component Analysis.	1
MODULE II [11 hours]		
2.1	Basics of probability-random variables and statistical measures -	1
2.2	rules in probability	1
2.3	Bayes theorem and its applications- statistical estimation	1
2.4	Maximum Likelihood Estimator (MLE) - statistical summaries	1
2.5	Correlation analysis- linear correlation - regression analysis.	1
2.6	linear regression (using least square method)	2
2.7	Types of Analytics: Descriptive Analytics, Diagnostic Analytics, Predictive Analytics,	2
2.8	Prescriptive Analytics, Big Data Analytics, Web Analytics,	1
2.9	Social Media Analytics, Business Intelligence	1
MODULE III [14 hours]		
3.1	Introduction to data analysis and the EDA process.	1
3.2	Types of data: structured, unstructured, categorical, numerical.	1
3.3	Data collection techniques and sources (CSV files, APIs, databases).	2
3.4	Data cleaning: fixing rows and columns, handling missing data,	2
3.5	Data cleaning: standardizing values, treating invalid entries, removing duplicates.	2
3.6	Univariate analysis: distribution of individual variables.	1
3.7	Bivariate analysis: relationships between two variables.	2
3.8	Data visualization: histograms, box plots, scatterplots	2
3.9	Data visualization: pair plots, heatmaps.	1
MODULE IV [12 hours]		
4.1	Introduction to libraries: NumPy for numerical operations	1
4.2	Pandas for data manipulation, Matplotlib for visualization	2
4.3	SciPy for scientific computation.	1
4.4	Introduction to machine learning: overview of supervised, unsupervised, and reinforcement learning.	2
4.5	Key algorithms: regression, classification (logistic, Naïve Bayes), clustering (K-means).	2
4.6	Model training and testing using scikit-learn.	1

4.7	Evaluation metrics: accuracy, precision, recall, F1 score, confusion matrix.	1
4.8	End-to-end implementation of a basic machine learning pipeline with real-world datasets.	2

CO Assessment Questions	
CO-1	1. Define conditional probability and solve a problem involving Bayes' Theorem using real-world data. [6 marks] **(Remember and Apply)** 2. A dataset contains exam scores of 100 students. Calculate the mean, median, mode, variance, and standard deviation. Interpret your results. [6 marks] **(Apply)** 3. Compare and contrast population and sample distributions. Provide examples where sampling distribution plays a critical role.[5 marks] **(Apply)**
CO-2	1. Given two vectors, compute their dot product, norm and the distance between them. [5 marks] **(Apply)** 2. For a given 3×3 matrix, calculate its determinant, inverse and eigenvalues using NumPy [6 marks] **(Apply)** 3. Explain the role of Singular Value Decomposition (SVD) in dimensionality reduction and demonstrate with a sample dataset.[6 marks] **(Remember and Apply)**
CO-3	1. Collect a small dataset from a public source (e.g., Kaggle or UCI), identify missing values and demonstrate how to handle them using Pandas. [5 marks] **(Apply and Analyze)** 2. Perform univariate and bivariate analysis on a dataset. Include visualizations (boxplots, histograms, scatterplots) and interpret the patterns. [6 marks] **(Apply and Analyze)** 3. Discuss the role of outlier detection in data cleaning. Use a boxplot to identify outliers in a numeric feature and explain your treatment method.[5 marks] **(Apply and Analyze)**
CO-4	1. Write Python code to read a CSV file, display summary statistics and plot a histogram using Pandas and Matplotlib.[6 marks] **(Apply and Analyze)** 2. Using NumPy, create two matrices and perform operations: addition, multiplication, transpose, and trace.[6 marks] **(Apply)** 3. Use Seaborn to create a heatmap showing correlation between features in a dataset. Interpret the visual result. [6 marks] **(Analyze)**

Prepared by: Dr. Sreeraj R, Professor; Dr. Krishnadas J, Associate. Professor; Dr. Asha S, Associate. Professor, Department of Computer Science Engineering

24HUT005	ENGINEERING ECONOMICS	L	T	P	R	C	Year of Introduction
		2	0	0	0	2	2024

Preamble:
To provide students with fundamental concepts of economics related to engineering industry, understanding of how price and output determined in different markets, macroeconomic concepts and to deliver the basic concepts of value engineering.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	To learn the basic economic concepts and to understand the fundamentals of various economic issues. **[Understand]**
CO 2	To acquire knowledge regarding the functioning of firms in different market situations and to develop decision making capability by applying concepts relating to cost and revenue. **[Apply]**
CO 3	To demarcate the macro economic principles of monetary and fiscal systems, national income and stock market. **[Understand]**
CO 4	To solve simple business problems using break -even analysis, capital budgeting techniques, and bring to bear the possibilities of value analysis and value engineering. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1		2			2	2		2		3	3
CO2		2			2	2		2		3	3
CO3		2			2	2		2		3	3
CO4		2			2	2		2		3	3

Assessment Pattern for Theory Component

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate				
Create				

Mark Distribution of CIA

Course Structure	Theory [L]					
	Attendance	**Assignment**	**Test-1**	**Test-2**	**Case Study**	**Total Marks**
2-0-0-0	5	5	10	10	20	50

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	50	50	2 hours

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 2	2 Questions from each module. Any full 6 Questions, each carrying 3 marks (6x3 =18 marks)	2 questions will be given from each module, of which 1 question should be answered. Each question can have a maximum of 3 subdivisions. Each question carries 8 marks. (4x8 = 32 marks)	50

SYLLABUS

MODULE I: DEMAND AND SUPPLY ANALYSIS [7h]

Basic Economic Concepts- Central problems of an economy -Production Possibility Curve-Utility-Law of diminishing marginal utility-Law of equi marginal utility- Law of Demand and Supply-Elasticity of Demand-Measurement of elasticity and its applications-Market Equilibrium-Changes in demand and Supply- its effects-Consumer surplus and producer surplus-Production functions in the short and Long run-Economies of scale-Internal and External economies-Cobb-Douglas Production Function. Taxation-Direct and indirect tax-Value Added Tax -Goods and Service Tax-Deadweight Loss. Case study on discounts for products in E-commerce.

Self-Study (8h):

1. Read and summarise what is economy and economics.
2. Read and make note on how does a consumers utility change when their income increases? Explain with the help of normal and inferior goods?
3. Explain the factors affecting the market demand of a commodity?
4. Study and make report on Impact of GST on small business in your city.

MODULE II: MARKET STRUCTURE [7h]

Costs Concepts- Social cost, Private cost-Explicit and Implicit cost-Sunk cost- Opportunity cost-Short run and long run cost curves-Revenue concepts- shut down point-Markets-Perfect competition- Monopoly-Monopolistic Competition-Oligopoly (price and output determination)-Non- price competition-Product pricing-Methods of product pricing. Case study on Monopolistic competition (Industry- consumer electronics).

Self-Study(8h):

1. Explain cost estimation techniques for engineering projects?
2. Read and summarise fixed and variable cost?
3. With real life example explain opportunity cost?
4. Explain the importance and methods of product pricing?

MODULE III: MACRO ECONOMIC CONCEPTS [7h]

National income -Concepts-Methods of estimating National income -Circular flow of income in two and four sector economy-Business financing -Bonds and shares- Financial Market-Stock market -Functions-Problems faced by the Indian stock market-Demat Account and Trading Account-Stock market indicators-SENSEX And NIFTY. Meaning and functions of Money-Central Banking-Inflation-Causes and effects -Measures to control inflation- Monetary and fiscal policies-Deflation-Case study on ”Impact of rising food prices on middle income house holds in your city”.

Self-Study (8h):

1. Read and Summarise how the national income of India is calculated?
2. Explain the causes of inflation?
3. Study and make report on:“A New Investor's Journey in Stock Market Trading"
4. Explain the impact of deflation in an economy?

MODULE IV: VALUE ANALYSIS AND VALUE ENGINEERING [7h]

Value Analysis and Value Engineering-Cost value, -Exchange value, -Use value-, Esteem value-Aims, Advantages and Application areas of value engineering-Value Engineering Procedure-Break-even-Analysis -Capital Budgeting-Time value of money-Net Present Value Method-Benefit Cost Ratio-Internal Rate of Return-Payback-Accounting Rate of Return-Decision tree analysis-Profit and balance sheet analysis-Game theory application in engineering. Case study on Value addition in food processing industry.

Self -Study (8h):

1. Explain the Time value of money in project evaluation?
2. Read and summarise the importance of cost benefit analysis?
3. Explain engineering decision- making under uncertainity?
4. Study and make report on” The rise of Gig economy and its impact on engineers”.
5. Explain Nash equilibrium?

Textbooks

1. H. G. Thuesen and W. J. Fabrycky, *Engineering Economy*, 4th ed., PHI Learning Pvt. Ltd.,

1966.
2. G. Geetika, P. Ghosh, and P. R. Choudhury, *Managerial Economics*, 2nd ed., Tata McGraw-Hill Education, 2015.
3. R. Panneerselvam, *Engineering Economics*, 2nd ed., PHI Learning Pvt. Ltd., 2013.

Reference books

1. L. T. Blank and A. J. Tarquin, *Engineering Economy*, 7th ed., McGraw-Hill Education, 2013.
2. M. Y. Khan, *Indian Financial System*, 7th ed., Tata McGraw-Hill Education, 2011.
3. D. G. Newnan and J. P. Lavelle, *Engineering Economic Analysis*, 9th ed., Engineering Press, Texas, 2002.
4. C. S. Park, *Contemporary Engineering Economics*, 3rd ed., Prentice Hall of India Pvt. Ltd., 2001.

NPTEL/SWAYAM Courses for reference:

1. NPTEL: Principles of Economics[IIT Madras] https://onlinecourses.nptel.ac.in/noc23_ec06/preview
2. NPTEL:Engineering Economic Analysis [IIT Roorkee] https://onlinecourses.nptel.ac.in/noc23_ec03/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [28 hours]
	MODULE I [7 hours]	
1.1	Basic Economic Concepts-Central Problems of an economy-Production possibility curve-Utility -Law of Diminishing Marginal Utility-Law of equi -marginal utility.	2
1.2	Law of Demand and Supply-Elasticity of Demand-Measurement of Elasticity and its applications.	1
1.3	Market Equilibrium - Changes in demand and supply-its effects-Consumer Surplus and Producer Surplus.	2
1.4	Production function in the Short and long run.	1
1.5	Economies of Scale-Internal and external economies-Cobb -Douglas production function, Taxation, Dead weight loss.	1
	MODULE II [7 hours]	
2.1	Cost Concepts- Social cost -Private cost -Explicit and implicit cost-Sunk cost- Opportunity cost.	1
2.2	Short run and Long run cost Curves-Revenue Concepts. Shut down point.	1
2.3	Markets-Perfect competition - Monopoly.	2
2.4	Monopolistic competition - Oligopoly.	2
2.5	Non-price Competition - Product pricing- Methods of Product Pricing.	1
	MODULE III [7 hours]	
3.1	National Income-Concepts-Methods of estimating national income.	2

3.2	Circular flow of income in two and four sector economy.	1
3.3	Business Financing-Bonds and Shares.	1
3.4	Financial market-Money market and Capital market.	1
3.5	Stock Market-Functions-Problems faced by the Indian Stock Market.	1
3.6	Meaning and functions of money, inflation and deflation.	1
MODULE IV [7 hours]		
4.1	Value analysis and value engineering-Cost value-Exchange value- Use value-Esteem value-Aims, Advantages and its Application- Areas of Value Engineering.	1
4.2	Value Engineering Procedure	1
4.3	Break- even- analysis	1
4.4	Capital Budgeting-Time value of money-Net Present Value Method-Benefit Cost Ratio-Internal Rate of Return-Payback-Accounting Rate of Return.	2
4.5	Decision tree analysis - Profit and balance sheet analysis - Game Theory application in engineering..	2
CO Assessment Questions		
CO-1	1. Examine why the problem of choice arise? **(Apply)** 2. Explain central economic problems? **(Analyze)** 3. Outline how do we solve the basic economic problems? **(Apply)** 4. Interpret the relation between price and demand? **(Apply)**	
CO-2	1. Explain shut down point? **(Analyze)** 2. Explain why monopolist called a price taker? **(Analyze)** 3. Examine the equilibrium of a firm under monopolistic competition? **(Apply)** 4. Outline the methods of product pricing? **(Apply)**	
CO-3	1. Explain the methods of estimating national income? **(Analyze)** 2. Distinguish between bonds and shares? **(Analyze)** 3. Examine the functions of money? **(Apply)** 4. Outline problems faced by Indian stock market? **(Apply)**	
CO-4	1. Explain break even analysis? **(Analyze)** 2. Examine capital budgeting methods? **(Apply)** 3. Distinguish between exchange value and use-value? **(Analyze)** 4. Diagrammatically explain decision tree analysis? **(Analyze)**	
Prepared by: Ms. Vini Valsan, Asst. Professor, Department of Applied Science & Humanities		

24BTL307	BIOCHEMISTRY LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble:

By engaging in this laboratory, students will develop analytical, technical, and problem-solving skills, preparing them for advanced studies, industrial applications, and research-driven careers in the life sciences. This laboratory emphasizes the preparation and handling of reagents, the quantitative and qualitative estimation of biomolecules, and the use of sophisticated analytical techniques for bio molecular characterization. Through structured experiments, students will develop competencies in protein, carbohydrate, lipid, and nucleic acid analysis, enabling them to interpret biochemical phenomena accurately and critically assess experimental outcomes.

Prerequisite: NIL

Course Outcomes: After the completion of course the student will be able to

CO1	Prepare reagents for various qualitative and quantitative experiments related to Biochemistry. **[Understand]**
CO2	Apply the knowledge gained to perform quantitative estimation for biomolecules like protein, reducing sugars, cholesterol and nucleic acids. **[Apply]**
CO3	Isolate a component from a biological sample and perform an assay. **[Evaluate]**
CO4	Apply appropriate biochemical methods and equipment to perform experiments and maintain detailed records of reagent preparation, experimental procedures, and results. **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1						2			3	3	3
CO2						2			3	3	3
CO3						2			3	3	3
CO4						2			3	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tools	
	Classwork	Test1
Remember		
Understand	√	√
Apply	√	√
Analyse	√	
Evaluate	√	
Create	√	

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-3-0	5	25	20	50

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hours

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:
(a) Procedure/Preliminary Work/Design/Algorithm (10 Marks)
(b) Conduct of Experiment/Execution of Work/Programming (15 Marks)
(c) Result with Valid Inference/Quality of Output (10 Marks)
(d) Viva Voce (10 Marks)
(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

Safety guidelines and ethical considerations in the lab

Qualitative tests for Carbohydrates

- Molisch's, Benedict's, Barfoed's and Seliwanoff's tests.
- Interpretation based on color changes.

Qualitative tests for Amino Acids

- Ninhydrin test, Biuret test, Xanthoproteic test.
- Interpretation based on color changes.

Qualitative Analysis of Lipids

- Identify the presence of fats using tests like Sudan III, acrolein, and grease spot.
- Interpretation based on color changes.

Quantitative estimation of sugars (any one)

- Estimation of reducing sugars by Benedict's method.
- Estimation of reducing sugars by the DNS method.

Quantitative estimation of amino acid by Ninhydrin method

- Spectrophotometric measurement.
- Linear regression and calculation from standard graph.

Quantitative Estimation of Proteins by Lowry's or Bradford Assay

- Spectrophotometric measurement.
- Linear regression and calculation from standard graph.

Quantitative estimation of cholesterol by Zak's method

- Spectrophotometric measurement.
- Linear regression and calculation from standard graph.

Quantitative estimation of DNA by Diphenylamine reagent method

- Spectrophotometric measurement.
- Linear regression and calculation from standard graph.

Quantitative estimation of RNA by Orcinol reagent method

- Use of yeast or plant extracts.
- Comparison with known standards.

Estimation of DNA by Diphenylamine Method

- Quantification from a biological sample.
- Colorimetric analysis.

UV spectra of (i) DNA (ii) Protein

- Determination of absorption maxima

Saponification of fats

- Understanding foaming and emulsification

Paper chromatography of amino acids

- Solvent system selection
- Separation of amino acids

Thin layer chromatography of fats

- Solvent system selection
- Rf value calculation

Protein precipitation by ammonium sulphate

- Stepwise precipitation for protein fractionation.
- Centrifugation and filtration.

Self-Study (24h):

1. Principle and applications of spectrophotometry in Biochemistry
2. Protein quantification techniques: Comparison of Lowry, Bradford, and BCA methods
3. Use of biochemical techniques in clinical diagnostics
4. Buffer systems in biological fluids and their significance
5. DNA and RNA quantification – UV vs Colorimetric methods

Text books

1. Sadasivam, S., and A. Manickam, *Biochemical Methods*, 2nd ed. New Delhi, India: New Age International (P) Ltd., 1996.
2. K. Wilson and J. Walker, *Principles and Techniques of Biochemistry and Molecular Biology*, 7th ed. Cambridge, U.K.: Cambridge Univ. Press, 2018.
3. R. F. Boyer, *Modern Experimental Biochemistry*, 3rd ed. India: Pearson Education, 2002.
4. A. J. Ninfa, D. P. Ballou, and M. Benore**,** *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*. Hoboken, NJ, USA: John Wiley & Sons, 2009.

LIST OF EXPERIMENTS

No.	Experiments
1	Safety guidelines and ethical considerations in the lab
2	Qualitative tests for carbohydrates

3	Qualitative tests for amino acids
4	Qualitative tests for lipids
5	Quantitative estimation of sugars (any one) Estimation of reducing sugars by Benedict's method. Estimation of reducing sugars by the DNS method.
6	Quantitative estimation of amino acid by Ninhydrin method
7	Quantitative estimation of proteins from egg albumin by Lowry's method.
8	Quantitative estimation of cholesterol by Zak's method
9	Quantitative estimation of DNA by Diphenylamine reagent method.
10	Quantitative estimation of RNA by Orcinol reagent method.
11	UV spectra of (i) DNA (ii) Protein
12	Saponification of fats
13	Paper chromatography of amino acids.
14	Thin layer chromatography of fats
15	Protein precipitation by ammonium sulphate
**A minimum of 10 experiments must be performed.*	
CO Assessment Questions	
CO1	1. Define molarity, normality, and buffer capacity in the context of reagent preparation. **(Understand)** 2. List the essential reagents required for protein precipitation, enzyme activity assays, and lipid extraction. **(Understand)** 3. Describe the role of pH and ionic strength in biochemical reagent preparation. **(Apply)** 4. A researcher needs to prepare a stable enzyme reaction buffer. What key factors should they consider? **(Analyze)**
CO2	1. Design a protocol for isolating total protein from a tissue sample. How would you ensure minimal protein degradation? **(Analyze)** 2. Compare two different methods for DNA extraction from a biological sample. Which method is more effective for high-yield and purity. **(Analyze)** 3. During lipid isolation from a biological sample, the extracted fraction appears contaminated with proteins. How would you refine the protocol to improve selectivity? **(Evaluate)** 4. Evaluate the advantages and limitations of ELISA vs. spectrophotometric methods for quantifying biomolecules in clinical diagnostics. **(Evaluate)**

CO3	1. Suggest ways to improve the sensitivity and accuracy of the reducing sugar estimation assay. **(Analyze)** 2. A student obtains inconsistent values while estimating cholesterol in serum samples. What possible errors might be affecting the results? **(Analyze)** 3. Compare the advantages and limitations of spectrophotometric vs. fluorometric methods for nucleic acid quantification. **(Analyze)** 4. Discuss why blank corrections are essential in quantitative biochemical assays. **(Analyze)**
CO4	1. Describe the procedure for calibrating a spectrophotometer before performing an experiment. **(Analyze)** 2. How does calibration impact result accuracy? **(Analyze)** 3. How would you select an appropriate biochemical method for the quantification of an unknown protein sample? **(Analyze)** 4. A researcher needs to quantify DNA purity using a UV-Vis spectrophotometer. Explain how absorbance readings at 260 nm and 280 nm determine sample quality. **(Analyze)**
Prepared by: Dr. P Praveena, Asst. Professor, Department of Biotechnology	

24BTL308	MICROBIOLOGY LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble:
This course provides hands-on training in core microbiological techniques including microscopy, staining, microbial isolation, and identification. Students will develop practical skills in aseptic handling, cultivation, and analysis of microorganisms, while understanding their significance in health, environment, and industry. Emphasis is placed on biosafety, accurate documentation, and scientific reporting.

Prerequisite: NIL

Course Outcomes: After the completion of course the student will be able to

CO1	Demonstrate proper usage of microscope and visually recognize the microscopic characteristics of bacteria **[Apply]**
CO2	Evaluate and apply appropriate laboratory techniques for isolation, characterization, propagation and enumeration of microorganisms in a given sample. **[Create]**
CO3	Design methods to understand and appreciate the impact of microorganisms on agriculture, environment, ecosystem and human health. **[Create]**
CO4	Apply appropriate microbiological laboratory methodology and instruments in accordance with current laboratory safety protocol and able to document protocols and results. **[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2				2			3	3	
CO2	2	2				2			3	3	
CO3	2	2				2			3	3	
CO4	2	2				2	1		3	3	

Assessment Pattern

Bloom's Category	Continuous Assessment Tools	
	Classwork	**Test1**
Remember		
Understand	√	√
Apply	√	√
Analyse	√	
Evaluate	√	
Create	√	

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-3-0	5	25	20	50

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	50	50	2 hours

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:
(a) Procedure/Preliminary Work/Design/Algorithm (10 Marks)
(b) Conduct of Experiment/Execution of Work/Programming (15 Marks)
(c) Result with Valid Inference/Quality of Output (10 Marks)
(d) Viva Voce (10 Marks)
(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

Introduction to Laboratory Safety and Equipment:

- Orientation to laboratory safety protocols and proper handling of biological materials.
- Familiarization with laboratory instruments such as incubators, autoclaves, microscopes, and biosafety cabinets.

Aseptic Techniques and Media Preparation:

- Principles and practices of aseptic transfer to prevent contamination.
- Preparation of various culture media (nutrient agar, broth) for microbial cultivation.

Microscopy and Staining Techniques:

- Use of bright-field microscopy to observe microbial morphology.
- Simple staining to determine cell shape and arrangement.
- Differential staining methods: **Gram Staining and Endospore staining**

Isolation and Cultivation of Microorganisms:

- Techniques for isolating pure cultures:
  - **Streak Plate Method:** Isolation of individual colonies.
  - **Spread and Pour Plate Methods:** Quantitative isolation and enumeration.
- Cultivation of bacteria, fungi, and yeast under various environmental conditions.

Enumeration of Microorganisms:

- Direct methods:
  - **Viable Plate Counts:** Determination of colony-forming units (CFUs).
  - **Most Probable Number (MPN):** Estimation of microbial populations in samples.
- Indirect methods:
  - **Turbidimetric Measurements:** Using a spectrophotometer to assess cell density.

Biochemical Characterization of Microorganisms:

- Performing tests to identify microbial metabolic activities:
  - **Catalase Test:** Detection of catalase enzyme activity.
  - **Oxidase Test:** Identification of cytochrome c oxidase presence.
  - **Carbohydrate Fermentation Tests:** Determining the ability to ferment sugars.
  - **IMViC Tests:** Series of tests (Indole, Methyl Red, Voges-Proskauer, Citrate) for enteric bacteria identification.

Antimicrobial Susceptibility Testing:

- Methods to assess microbial sensitivity to antibiotics:
  - **Disk Diffusion Method (Kirby-Bauer Test):** Measuring zones of inhibition to evaluate antibiotic efficacy.
  - **Broth Dilution Method:** Determining minimum inhibitory concentration (MIC) of antibiotics.

Control of Microbial Growth:

- Evaluating the effects of physical agents:
  - **Heat:** Assessing thermal death time and decimal reduction time.
  - **Ultraviolet Radiation:** Studying the impact of UV light on microbial viability.
- Evaluating the effects of chemical agents:
  - **Disinfectants and Antiseptics:** Assessing efficacy using the phenol coefficient method.

Microbial Growth Curve Analysis:

- Monitoring bacterial growth over time to construct growth curves.
- Determining key growth parameters: lag phase, log phase, stationary phase, and death phase.

Water and Food Microbiology:

- Microbiological analysis of water samples:
  - **Presumptive Test:** Detection of coliforms as indicators of contamination.
- Microbiological analysis of food samples:
  - **Standard Plate Count:** Enumeration of viable microorganisms in food.

Preservation of Microbial Cultures:

- Techniques for long-term storage and maintenance of microbial strains:
  - **Refrigeration:** Short-term storage at low temperatures.
  - **Deep Freezing:** Long-term

Self-Study (24h):

1. Biosafety Levels (BSL 1–4): Features and laboratory examples
2. Common lab accidents in microbiology and how to prevent them
3. Principles of autoclaving and validation using biological indicators
4. Common errors in Gram staining and how to troubleshoot them
5. Role of oxygen scavengers in anaerobic culture systems
6. Common disinfectants in hospitals and their mechanisms
7. UV sterilization in water purification: Mechanism and limitations
8. Software tools for plotting and analyzing microbial growth curves (Excel)
9. Microbial culture collections and repositories (e.g., ATCC, MTCC)

Text books

1. A. J. Ninfa, D. P. Ballou, and M. Benore, *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*. Hoboken, NJ, USA: John Wiley & Sons, 2009.
2. J. G. Cappuccino and C. T. Welsh, *Microbiology: A Laboratory Manual*, 12th ed. Hoboken, NJ, USA: Pearson Education, 2020.

3. J. P. Harley, *Laboratory Exercises in Microbiology*, 11th ed. New York, NY, USA: McGraw-Hill Education, 2021.

LIST OF EXPERIMENTS

No.	Experiments
1.	Introduction to Laboratory Safety and equipments such as such as incubators, autoclaves, microscopes, and biosafety cabinets
2.	Preparation of various culture media for microbial cultivation.
3.	Simple staining to determine cell shape and arrangement.
4.	Differential staining methods: Gram Staining and Endospore staining
5.	Isolation and Cultivation of Microorganisms using plating methods
6.	Cultivation of bacteria, fungi, and yeast under various environmental conditions
7.	Enumeration of Microorganisms by viable plate counts
8.	Enumeration of Microorganisms using Haemocytometer
9.	Enumeration of Microorganisms by Turbidimetric measurements
10.	Biochemical Characterization of Microorganisms using Catalase, Oxidase and Carbohydrate fermentation tests
11.	Biochemical Characterization of Microorganisms using IMViC Tests
12.	Antimicrobial Susceptibility Testing using Disk Diffusion Method (Kirby-Bauer Test)
13.	Antimicrobial Susceptibility Testing using Broth Dilution Method
14.	Control of Microbial Growth and Evaluating the effects of physical and chemical agents
15.	Microbial Growth Curve Analysis.
16.	Microbiological analysis of water samples.
17.	Microbiological analysis of food samples
18.	Techniques for long-term storage and maintenance of microbial strains.

**A minimum of 10 experiments must be performed.*

CO Assessment Questions

CO1	1. Prepare a bacterial slide using Gram staining and interpret the observed morphology and staining pattern under the microscope. **(Analyze)** 2. Compare the cellular arrangements and structures of cocci, bacilli, and spirilla under the compound microscope. **(Apply)** 3. Identify and record the presence of specific bacterial structures (e.g., capsule, endospore, flagella) using appropriate special staining methods. **(Apply)** 4. Observe and differentiate between live and dead bacterial cells using a suitable staining method (e.g., vital staining with Trypan Blue or methylene blue). **(Apply)**

CO2	1. Perform streak plate and pour plate techniques to isolate pure cultures from a mixed microbial sample. **(Apply)** **2.** Analyze colony morphology and perform biochemical tests to characterize an unknown bacterial isolate. **(Analyze)** 3. Enumerate bacterial population using serial dilution and standard plate count method; calculate CFU/mL. **(Apply)** 4. Select suitable culture media and incubation conditions for isolating a specific class of microorganisms (e.g., fungi or coliforms). **(Apply)**
CO3	1. Develop a laboratory protocol to test water samples for coliform contamination using MPN or membrane filtration technique. **(Analyze)** 2. Design an experiment to observe the antimicrobial effect of natural or synthetic agents on pathogenic bacteria. **(Create)** 3. Set up a simple experiment to demonstrate the nitrogen-fixation ability of a soil bacterium (e.g., Rhizobium). **(Create)** 4. Propose a method to test the effectiveness of food preservation techniques in reducing microbial spoilage. **(Evaluate)**
CO4	1. Demonstrate aseptic techniques during media preparation, inoculation, and disposal of microbial cultures. **(Analyze)** 2. Record all steps, observations, and inferences of a biochemical test in a structured laboratory notebook format. **(Apply)** 3. Use a spectrophotometer to monitor bacterial growth and document the growth curve graphically. **(Apply)** 4. Identify safety violations in a hypothetical lab scenario and recommend corrective measures in line with biosafety guidelines. **(Evaluate)**
Prepared by: Dr. Dhanya Gangadharan, Associate Professor, Department of Biotechnology	

SEMESTER-IV
SYLLABUS

24MAT421	PROBABILITY DISTRIBUTIONS, NUMERICAL METHODS & TRANSFORMS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
This course lays a strong foundation in probabilistic modelling, statistical inference, numerical methods, and transforms, equipping students with the tools to tackle complex real-world problems with confidence and precision. These concepts enable engineers to analyse data, model uncertainties, and design reliable, efficient systems across diverse engineering domains.

Prerequisite: Basics of statistics and probability laws, Fundamentals of differentiation and integration.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Develop the ability to model and analyse real-world situations involving uncertainty using discrete and continuous probability distributions. **[Apply]**
CO 2	Apply statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population. **[Apply]**
CO 3	Utilize numerical methods to differentiate and integrate multi-variable functions, extending their application to advanced engineering models. **[Apply]**
CO 4	Determine the transforms of functions and understand their properties. **[Apply]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2							
CO2	3	2	2	2							
CO3	3	2	2	2	2						
CO4	3	2	3								

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze				
Evaluate				
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]				
	Attendance	Assignment	Test-1	Test-2	Total Marks
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours
End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Probability Distributions [9h]

(**Text 1: Relevant topics from sections 3.1,3.2,3.3,3.4,3.6,4.1,4.2,4.3,4.4)**

Discrete and continuous random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the Binomial distribution, exponential and normal distributions.

Self-Study (14h):

1. Explain the probability mass function (PMF). Can you give an example of a discrete random variable?
2. Write down the significance of the expectation and variance in real-life contexts.
3. Under what conditions is a random variable said to follow a binomial distribution?
4. Derivation of the mean and variance of a Poisson distribution? Are they always equal?
5. Explain the Central Limit Theorem, and how does it relates to the normal distribution.
6. Identify which distribution to apply in real-life problems such as machine failures, survey results, or traffic patterns.

MODULE II: Statistical Inference [8h]

(**Text 1: Relevant topics from sections 1.1,7.1,7.2,8.1,8.2,8.3)**

Population and samples, Sampling distribution of the mean and proportion (for large samples only), Confidence interval for single mean and single proportions (for large samples only). Test of hypotheses: Large sample test for single mean and single proportion, small sample t-tests for single mean and equality of means of normal population.

Self-Study (13h):

1. Write a short note on the difference between a population and a sample in statistics.
2. Identify the population and sample in a given real-world example (e.g., survey of college students).
3. Explain the difference between the standard deviation and the standard error.
4. Under what conditions can you apply the normal approximation for proportions?
5. When do you use the t-test instead of the Z-test? Explain with examples.
6. Relevance of probability and statistics in your branch of study.

MODULE III: Numerical Differentiation and Integration [9h]

(Text 2: Relevant topics from sections 19.3,19.5,21.1)

Newton's forward and backwards interpolation method, Lagrange's interpolation method, Solution of ordinary differential Equations-Euler and Classical Runge-Kutta method of second and fourth order, Numerical Integration- Trapezoidal rule and Simpson's rule.

Self-Study (13h):

1. How do you identify whether to use forward or backwards interpolation for a given data set with an example?
2. Explain the situations in which Lagrange's interpolation formula and Newton's methods can be applied.
3. What are the assumptions and limitations of Euler's method?
4. Review the motivation for using the Runge-Kutta methods over Euler's method.
5. Identify real-world problems where these numerical methods are applicable (e.g., physics, engineering, finance).

MODULE IV: Transforms [10h]

(Text 2: Relevant topics from sections 11.8,11.9)

(Text 3: Relevant topics from sections 23.1,23.2,23.3,23.4,23.5,23.6,23.7,23.8,23.15)

Fourier transform and inverse Fourier transform, basic properties (without proof),
Fourier sine and cosine transforms, inverse Fourier sine and cosine transforms, Z transform.

Self-Study (14h):

1. Explain the types of functions that are suitable for applying the Fourier transform.
2. When do we prefer to use the sine or cosine transform over the general Fourier transform? Verify with examples.
3. Importance of Transforms in Your Branch of Study.
4. Write a note on the properties of the Z-transform.
5. How do the Fourier and Z-transforms differ in terms of domain (continuous vs. discrete)?

Textbooks

1. J. L. Devore, *Probability and Statistics for Engineering and the Sciences*, 9th ed. Boston, MA, USA: Cengage Learning.
2. E. Kreyszig, *Advanced Engineering Mathematics*, 10th ed. Hoboken, NJ, USA: John Wiley & Sons, 2016.
3. B. S. Grewal, *Higher Engineering Mathematics*, 44th ed. New Delhi, India: Khanna Publishers, 2017

Reference books

1. N. P. Bali and M. Goyal, *Engineering Mathematics*, 8th ed. New Delhi, India: Goyal Laxmi Publications, 2011.
2. S. C. Chapra and R. P. Canale, *Numerical Methods for Engineers*, 8th ed. New York, NY, USA: McGraw-Hill Education, 2021.
3. A. Papoulis and S. U. Pillai, *Probability, Random Variables and Stochastic Processes*, 4th ed. New York, NY, USA: McGraw-Hill, 2002.
4. S. M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 6th ed. Cambridge, MA, USA: Academic Press, 2020.
5. S. K. Pundir, *Integral Transform Methods in Science and Engineering*, 1st ed. New Delhi, India: CBS Publishers & Distributors, 2017.

NPTEL/SWAYAM Courses for reference:

1. Dharmaraja, S. (2022). Introduction to Probability Theory and Statistics [Video course]. National Programme on Technology Enhanced Learning (NPTEL), IIT Delhi. https://archive.nptel.ac.in/courses/111/102/111102160/
2. Numerical Methods By Prof. Ameeya Kumar Nayak, Prof. Sanjeev Kumar, IIT Roorkee NPTEL :: Mathematics - NOC:Numerical methods

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	Discrete random variables, Probability distributions of Discrete random variables	1
1.2	Expectation, Mean, Variance	1
1.3	Binomial Distribution	2
1.4	Poisson Distribution, Poisson approximation to the binomial distribution	1
1.5	Continuous random variables, Probability distributions of Discrete random variables	1
1.6	Exponential Distribution	1
1.7	Normal distribution	2
	MODULE II [8 hours]	
2.1	Population and samples, Sampling distribution of the mean and proportion (for large samples only)	1
2.2	Confidence interval for single mean (for large samples only)	1

2.3	Confidence interval for single proportions (for large samples only)	1
2.4	Test of hypotheses:	1
2.5	Large sample test for single mean	1
2.6	Large sample test for single proportion	1
2.7	Small sample t-tests for single mean and equality of means of normal population	2
MODULE III [9 hours]		
3.1	Newton's forward & backwards interpolation method	2
3.2	Lagrange's interpolation method	1
3.3	Solution of ordinary differential equations-Euler method	1
3.4	Solution of ordinary differential equations- Classical Runge-Kutta method of second order	1
3.5	Solution of ordinary differential equations-Kutta method of fourth order	2
3.6	Numerical integration-Trapezoidal rule	1
3.7	Numerical integration- Simpson's rule	1
MODULE IV [10 hours]		
4.1	Fourier transform and inverse Fourier transform	2
4.2	Basic properties(without proof)	1
4.3	Fourier sine and cosine transforms	2
4.4	Inverse sine and cosine Fourier transform	1
4.5	z transform	2
4.6	Properties of Z transform	2
CO Assessment Questions		

CO-1	1. A problem in Mechanics is given to three students A, B, C whose chances of solving it are ½, 1/3 and ¼ respectively. What is the probability that the problem will be solved. **[Apply]** 2. If a random variable has a Poisson distribution such that P(1) = P(2) then find mean of the distribution and P(4). **[Analyze]** 3. The lifetime (in hours) of a water pump used at a construction site follows an exponential distribution with a mean lifetime of 2000 hours**.** (i) What is the probability that a pump fails before 1000 hours**?** (ii) What is the probability that a pump operates for more than 3000 hours without failure? **[Apply]** **Team Work**: 1. A company launches a new email marketing campaign. Based on past data, there's a 20% chance that any given customer will respond positively to the email. If the company sends the email to 15 customers: What is the probability that exactly 3 customers respond positively? What is the probability that at most 2 customers respond positively? How would the probability change if the success rate increased to 30%? 2. The amount of rainfall (in cm) during a storm at a construction site is modeled as a continuous random variable X with the following probability density function (PDF): $f(x) = \begin{cases} \frac{1}{5}, & 0 \le x \le 5 \\ 0, & \text{otherwise} \end{cases}$ (i) Verify whether f(x) is a valid probability density function. (ii) What is the probability that the rainfall during a storm is less than 2 cm? (iii) What is the probability that the rainfall is between 1 cm and 3 cm? Compare the answer of (ii) when rainfall is less than 3cm. and compare the answer of (iii) when rainfall is between 1.5cm and 3.5cm.

CO-2	1. Two independent samples of students from two colleges give the following heights (in cm): ● College A (n = 8): Mean = 170, SD = 6 ● College B (n = 10): Mean = 174, SD = 5 Test at 5% level whether the mean heights differ significantly? **[Apply]** 2. Explain the importance of random sampling in statistical inference. **[Understand]** 3. In a survey of 600 people, 360 support a proposed law. Can we conclude at 1% significance level that the true proportion exceeds 0.55? **[Apply]** **Team Work**: 1. Discuss and list examples of **Type I and Type II errors** in practical scenarios (e.g., drug approval, quality control, court verdicts). 2. Debate: "Larger samples always give more accurate results in statistics."
CO3	1. Using Newton's method of interpolation find sin 52^0 from the data given below. when sin 45^0 = 0.7071, sin 50^0 = 0.7660, sin 55^0 = 0.8192, sin 60^0 = 0.8660? **[Apply]** 2. From the following data find log 656 No. : 654 658 659 661 Log : 2.8156 2.8182 2.8189 2.8202 **[Apply]** 3. Use Trapezoidal rule to estimate the integral $\int_0^2 e^{x^2} dx$ taking 10 intervals.**[Apply]** **Team Work**: Solve the ODE $\frac{dy}{dt} = -2y + e^{-t}$, $y(0) = 1$, $t \in [0, 5]$ using Runga Kutta method of 4^{th} order (step size= h = 0.1) and compare the answer obtained using MATLAB+'s ordinary differential equation solver.
CO-4	1. Use the time-shifting property to find the Fourier transform of f(x – x_0) given the transform of f(x). **[Apply]** 2. Explain how the convolution theorem simplifies the process of solving differential equations using Fourier transforms. **[Apply]**

	Team Work: 1. Each team discusses and presents one **property** of Fourier or Z-transform (e.g., time shift, linearity, scaling). 2. Each team researches an application of Fourier or Z-transform in engineering (e.g., image compression, signal filtering).
Prepared by: Ms. Swapna Joseph, Asst. Professor, Ms. Rani Thomas, Asst. Professor, Department of Applied Science and Humanities	

24BTT402	CELL BIOLOGY & GENETICS	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:

By studying Cell Biology, students will gain insights into the composition and organization of cells, their physiological functions, signaling mechanisms, and interactions within multicellular organisms. The field of Genetics complements this knowledge by elucidating how genetic material is transmitted, regulated, and altered across generations, influencing phenotypic traits and species diversity. Together, these disciplines form the cornerstone of modern biotechnology, molecular medicine, and genomic research.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Understand the structure and function of cells, their organelles, and cellular processes. **[Understand]**
CO 2	Identify the regulation of the cell cycle and its implications for growth, development, and disease.**[Understand]**
CO 3	Apply fundamental principles of genetics to analyze gene expression, inheritance patterns, and the impact of mutations on phenotype. **[Apply]**
CO 4	Analyze the role of genetic and cellular mechanisms in health, disease, and biotechnology applications. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1						3	3				
CO2						3	3				
CO3				2		3	3				
CO4				2		3	3				

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember				
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate				
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Lecture [L]				
	Attendance	Assignment	Test-1	Test-2	Total Marks

3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 1	8 Questions (2 Questions from each module), each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Introduction to Cell Structure 12h [9 L + 3T]

History and development of cell theory, structural differences between prokaryotic and eukaryotic, importance of cell biology in Biotechnology.

Cell Membrane: Structure & Transport: Fluid Mosaic Model of Membrane Structure, Lipid Bilayer and Membrane Proteins, Passive Transport: Diffusion & Osmosis, Active Transport: Pumps, Endocytosis & Exocytosis.

Tutorial:

Microscopic / model-based analysis of cell organelles, Research adaptations in extremophiles, Investigation on how membrane fluidity affects transport in different temperature conditions.

Self-Study (18h):

1. Comparative analysis various of cell types.
2. Evolutionary perspective on organelle development.
3. Analyze differences in cell structure and function between bacteria, archaea, and eukaryotic cells.
4. Investigate how cytoskeletal defects contribute to neurological disorders.

MODULE II: Cell organelles, Cytoskeleton and Cell Motility 12h [9 L + 3T]

Organelles and their functions: Nucleus – DNA storage, transcription regulation; mitochondria – energy production, aerobic respiration; endoplasmic reticulum (smooth & rough); golgi apparatus; lysosomes & peroxisomes; chloroplasts (in plants) – photosynthesis and carbon fixation; vacuoles; ribosomes.

Cytoskeleton and Cell Motility: Microtubules- structure and function; microfilaments (actin

filaments): cell shape & movement.

Tutorial:

Case study discussion on diseases linked to organelle dysfunction, Technical quiz on cell organelles, Organelle analogies-conceptual understanding

Self-Study (18h):

1. Cell Biology-week 4: https://onlinecourses.swayam2.ac.in/cec25_cy01/preview

MODULE III: Cellular Processes and Cell Signaling 12h [9 L + 3T]

Cell division: stages of mitosis, significance of mitosis in growth & development. Stages of meiosis. Differences Between Mitosis & Meiosis. Cell Cycle: Phases of the cell cycle. Role of checkpoints in cell cycle regulation. Cyclins and CDKs, apoptosis.

Cell Signaling: Basic principles. Receptor types- GPCRs, RTKs, ion Channels. Second messenger systems -cAMP, Ca2+, IP3. Role of kinases & phosphatases in signal cascades.

Tutorial:

Crossing over and genetic variability

1. Autophagy: overview of mechanism & role in cellular homeostasis
2. Case Study: Defective Signalling in Cancer

Self- Study (18h):

1. Experimental Techniques for Studying Cell Cycle
2. Cell Cycle in Stem Cells vs. Cancer Cells
3. Apoptosis in Development & Disease
4. Therapeutic Targeting of Apoptosis Pathways

MODULE IV: Principles of Genetics 12h [9 L + 3T]

Mendelian Inheritance & Non-Mendelian Traits- Mendel's Laws: monohybrid & dihybrid crosses, incomplete dominance & codominance; polygenic inheritance.

Genetic Linkage & Mapping- Chromosomal theory of inheritance, linked genes & crossing over.

Tutorial:

Problem-Solving in Mendelian Genetics-Solving Monohybrid & Dihybrid Crosses Using Punnett Squares, Predicting Phenotypic Ratios & Analyzing Real-World Examples, Discussion: Ethical Dilemmas in Gene Editing & Genetic Therapy.

Self-Study (18h):

1. Single-gene disorders: Cystic fibrosis, Sickle Cell Anaemia
2. Chromosomal Abnormalities (Down Syndrome, Turner Syndrome etc.)
3. Gene therapy approaches for genetic disorders

Reference books

1. G. Karp, Cell and Molecular Biology: Concepts and Experiments, 8th ed. Hoboken, NJ, USA: Wiley, 2020.
2. D. P. Snustad and M. J. Simmons, Principles of Genetics, 7th ed. Hoboken, NJ, USA: Wiley, 2015.
3. R. J. Brooker, Genetics: Analysis and Principles, 7th ed. New York, NY, USA: McGraw-Hill, 2020.
4. T. Strachan and A. Read, Human Molecular Genetics, 5th ed. New York, NY, USA: Garland Science, 2018.
5. T. A. Brown, Genomes, 5th ed. Boca Raton, FL, USA: CRC Press, 2023.
6. J. E. Krebs, E. S. Goldstein, and S. T. Kilpatrick, Lewin's Genes XII, 12th ed. Burlington, MA, USA: Jones & Bartlett Learning, 2017.
7. B. A. Pierce, Genetics: A Conceptual Approach, 6th ed. New York, NY, USA: Macmillan Learning, 2017.

Additional Tools for Self-Learning (Recommended)

- **MIT OpenCourseWare (Cell Biology & Genetics)** – Free university-level course materials. https://ocw.mit.edu/courses/7-03-genetics-fall-2004/
  Coursera: Introduction to Genetics & Evolution - Comprehensive genetics tutorials: https://www.coursera.org/learn/genetics-evolution
- **EdX: Molecular Biology & Biotechnology** – Courses on Cell Biology- https://www.edx.org/learn/cellular-biology/harvard-university-cell-biology-mitochondria

NPTEL/SWAYAM Courses for reference:

1. Cell Biology: Cellular organization, division and processes: https://onlinecourses.nptel.ac.in/noc24_bt18/preview
2. Basic Human Genetics: https://onlinecourses.swayam2.ac.in/cec21_bt21/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48 hours]
	MODULE 1 [12 hours]	
1.1	History and development of cell theory, structural differences between prokaryotic and eukaryotic, importance of cell biology in Biotechnology.	2
1.2	Cell Membrane: Structure & Transport: Fluid Mosaic Model of Membrane Structure, Lipid Bilayer.	2
1.3	Membrane Proteins.	1
1.4	Passive Transport: Diffusion & Osmosis.	2
1.5	Active Transport: Pumps.	1
1.6	Endocytosis & Exocytosis.	1

1.7	**Tutorials:** Microscopic / model-based analysis of cell organelles; Research adaptations in extremophiles; Investigation on how membrane fluidity affects transport in different temperature conditions.	3
MODULE II [12 hours]		
2.1	Organelles and their functions: Nucleus – DNA storage, transcription regulation.	2
2.2	Mitochondria – energy production, aerobic respiration; endoplasmic reticulum (smooth & rough); golgi apparatus; lysosomes & peroxisomes.	2
2.3	Chloroplasts (in plants) – photosynthesis and carbon fixation; vacuoles; ribosomes.	2
2.4	Cytoskeleton and Cell Motility: Microtubules- structure and function.	2
2.5	Microfilaments (actin filaments): cell shape & movement.	1
2.6	**Tutorials:** Case study discussion on diseases linked to organelle dysfunction; Technical quiz on cell organelles; Organelle analogies-conceptual understanding.	3
MODULE III [12 hours]		
3.1	Cell division: stages of mitosis, significance of mitosis in growth & development.	1
3.2	Stages of meiosis. Differences Between Mitosis & Meiosis.	2
3.3	Cell Cycle: Phases of the cell cycle. Role of checkpoints in cell cycle regulation.	2
3.4	Cyclins and CDKs, Apoptosis.	1
3.5	Cell Signaling: Basic principles. Receptor types- GPCRs, RTKs, ion Channels.	1
3.6	Second messenger systems -cAMP, Ca2+, IP3. Role of kinases & phosphatases in signal cascades.	2
3.7	**Tutorials:** Crossing over and genetic variability; Autophagy: overview of mechanism & role in cellular homeostasis; Case Study: Defective Signalling in Cancer.	3
MODULE IV [12 hours]		
4.1	Mendelian Inheritance & Non-Mendelian Traits- Mendel's Laws: monohybrid cross.	2
4.2	Dihybrid crosses, incomplete dominance.	2
4.3	Codominance; polygenic inheritance.	1
4.4	Genetic Linkage & Mapping.	2
4.5	Chromosomal theory of inheritance.	1
4.6	linked genes & crossing over.	1
4.7	**Tutorials:** Problem-Solving in Mendelian Genetics-Solving Monohybrid & Dihybrid Crosses Using Punnett Squares; Predicting	3

	Phenotypic Ratios & Analyzing Real-World Examples; Discussion: Ethical Dilemmas in Gene Editing & Genetic Therapy.	

CO Assessment Questions

CO-1	**3-Mark Questions** 1. Differentiate between prokaryotic and eukaryotic cells. **(Apply)** **2.** What is the function of the mitochondria in eukaryotic cells? **(Understand)** 3. Explain the role of ribosomes in protein synthesis. **(Apply)** 4. What are the major differences between plant and animal cells? **(Apply)** **9-Mark Questions** **1.** Compare and contrast the roles of microtubules, actin filaments, and intermediate filaments in cytoskeletal function. **(Apply)** 2. Analyze how the endomembrane system ensures coordinated cellular processes. **(Analyze)** 3. How does the structure of different organelles reflect their function? Provide examples. **(Analyze)** 4. Examine how defects in mitotic spindle formation lead to chromosomal abnormalities in cancer. **(Analyze)**
CO-2	**3-Mark Questions** 1. Define the role of cyclins and cyclin-dependent kinases (CDKs) in cell cycle regulation. **(Understand)** 2. Explain the significance of the G1 checkpoint in the cell cycle. **(Analyze)** 3. How does the S phase contribute to genetic stability? **(Analyze)** 4. How does mitotic failure lead to genetic abnormalities? **(Apply)** **9-Mark Questions** 1. Evaluate the impact of DNA damage on cell cycle regulation and its role in disease pathology. **(Evaluate)** 2. Discuss the role of apoptosis in maintaining tissue homeostasis and preventing tumor formation. **(Analyze)** 3. Analyze how cyclins and CDKs regulate cell cycle progression and discuss their implications in cancer development. **(Analyze)** 4. Evaluate the role of environmental and genetic factors in regulating the cell cycle and their implications for disease. **(Evaluate)**

CO-3	**3-Mark Questions** **1.** Define Mendel's Law of Segregation and explain its significance. **(Understand)** 2. Differentiate between dominant and recessive traits with examples**.** **(Apply)** 3. What is a monohybrid cross? Explain with a Punnett square. **(Understand)** 4. How does independent assortment contribute to genetic diversity? **(Apply)** **9-Mark Questions** 1. Analyze the differences between complete dominance, incomplete dominance, and codominance with suitable examples. **(Analyze)** 2. Evaluate the impact of mutations on inheritance patterns and genetic variability. **(Evaluate)** 3. Discuss sex-linked inheritance and analyze how it differs from autosomal inheritance. **(Understand)** 4. Examine the significance of genetic linkage and crossing over in inheritance patterns. **(Apply)**
CO-4	**3-Mark Questions** 1. Describe how genetic engineering aids in disease treatment. **(Apply)** 2. How do defects in apoptotic pathways lead to uncontrolled cell proliferation? **(Apply)** 3. Briefly explain the role of genetic screening in diagnosing hereditary diseases. **(Apply)** 4. What is the connection between mitochondrial dysfunction and neurodegenerative diseases? **(Apply)** **9-Mark Questions** 1. Analyze the significance of apoptosis and autophagy in disease pathology and therapy development. **(Analyze)** 2. How do mitochondrial disorders impact human health, and what biotechnology interventions address them? **(Analyze)** 3. Evaluate the significance of genetic mutations in disease development and discuss current therapeutic strategies. **(Analyze)** 4. Analyze the molecular basis of cancer progression and discuss therapeutic strategies targeting cell cycle regulation. **(Analyze)**
Prepared by: Dr. P.Praveena, Asst. Professor, Department of Biotechnology	

24BTT403	FLUID FLOW AND PARTICLE TECHNOLOGY	L	T	P	R	C	Year of Introduction
		3	1	0	0	4	2024

Preamble:
This course provides a foundational understanding of the principles and applications of fluid flow and particle technology essential for analyzing and designing systems in chemical and process engineering.

Prerequisite: A basic understanding of engineering mathematics, physics, and introductory thermodynamics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	**Apply** the fundamental principles of fluid flow and particle technology to solve engineering problems related to single-phase and multiphase flow systems. **[Apply]**
CO 2	**Analyze** the behavior of fluids and particles in various systems, such as pumps, reactors, and filtration units, identifying key factors like pressure drop, particle size distribution, and flow regimes to optimize system performance. **[Analyze]**
CO 3	**Design** efficient fluid transport and particle handling systems, including the selection of appropriate equipment, considering operational conditions, flow characteristics, and particle properties to enhance performance and energy efficiency. **[Apply]**
CO 4	**Analyze** and **design** solid-liquid separation processes and particle processing systems, evaluating factors like particle-fluid interactions, settling velocity and developing optimized solutions for industrial-scale operations. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO 6	PO7	PO8	PO9	PO10	PO11
CO1	3	2		2							
CO2	3	3		2	2						
CO3	3	2	3	2	2						
CO4	3	3	3	3	2						

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]				
	Attendance	Assignment	Test-1	Test-2	Total Marks
3-1-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Introduction to Fluid 12h [9L + 3T]

Definition of Fluid, continuum concept of fluid; Fluid Statics - Forces on fluids and hydrostatic equilibrium, Measurement of Pressure using different types of manometers. Forces on submerged bodies - Buoyancy, Stability of floating and submerged bodies. (Numerical problems) Introduction to fluid flow- Ideal fluid, Flow of incompressible fluids, flow visualization using the concept of streamline. Classification of flow - Steady and unsteady state flow, uniform and non-uniform flow, rotational and irrotational flow, velocity potential and stream function. Newtonian and non- Newtonian fluids: Momentum flux and Newton's Law of Viscosity, Rheology of fluids.

Tutorial:

Problem-solving on Properties of fluids, Numericals on Forces on Submerged bodies, Group Learning on Classification of fluid flow.

Self-Study(18h):

1. Research the definition of fluids and understand why substances like water, air, and gases are considered fluids. Focus on their ability to flow and deform under stress.
2. Learn about the fundamental differences between fluids and solids, such as how solids resist deformation, while fluids continuously deform when under shear stress.
3. Research practical applications of real fluids (e.g., water, oil, air) and how they differ from theoretical models.

4. Read examples of ideal fluids and understand their limitations. Note that real fluids are more complex and exhibit viscosity.
5. Virtual Lab Simulation Activity – Fluid Flow through Pipes

MODULE II: Flow Characteristics 12h [9L + 3T]

Laminar and Turbulent flow - Reynold's Experiment, Equations of Change for isothermal systems - Equation of Continuity, Qualitative treatment of Equation of Motion – Navier-Stoke's Equation and Euler equation (derivations not required). Flow in boundary layers: concept of types of drag and drag coefficient, Overview of boundary layer separation and wake formation. Flow through pipe - Bernoulli Equation (derivation required), Correction factors in Bernoulli Equation, Pump work – Numerical problems. Outline of pressure losses (Numerical problems not desired) in straight pipes and in fittings, concept of equivalent diameter.

Tutorial:

Problem-solving on Reynold's number, Continuity equation, Bernoulli's equation.

Self-Study(18h):

1. Practice solving simple problems using Bernoulli's equation and the continuity equation for incompressible fluid flow.
2. Learn how centrifugal force is used to increase the pressure and velocity of a fluid using rotating impellers.
3. Explore the thin region near solid surfaces where viscous forces are significant, and understand how it affects drag and flow separation.
4. Explore the difference between direct and indirect methods (e.g., positive displacement vs. velocity-based.

MODULE III: Internal incompressible viscous flow 12h [9L + 3T]

Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation (Derivation required); Shear stress and Velocity distribution in circular channel, energy consideration in pipe flow, relation between average and maximum velocity.

Introduction to turbulent flow in a pipe-Prandtl mixing length; Universal velocity distribution, head loss; friction factor-Fanning and Darcy, Moody diagram. Transportation and Metering of Fluids - Pumps- Reciprocating and Centrifugal pumps, Characteristics of centrifugal pumps - Priming, cavitation, NPSH, water hammer, loss of head and power in centrifugal pumps. Flow measurement - Introduction; general equation for internal flow meters; Orifice meter; Venturimeter; Weirs, concept of area meters: rotameter; Local velocity measurement: Pitot tube. Hot wire anemometer, mass flow meter.

Tutorial:

Problem Solving on Shear stress and Velocity distribution, Pump Selection, Parametric studies by simulating multiple flow rates.

Self- Study(18h):

1. Study how shear stress arises from velocity gradients in fluids, described by Newton's law of viscosity.

2. Explore how velocity varies parabolically in laminar flow through circular pipes (Hagen–Poiseuille equation).
3. Learn about the flatter velocity profile in turbulent pipe flow and empirical laws like the logarithmic velocity distribution.
4. Understand how shear stress includes both viscous and turbulent (Reynolds) stresses in turbulent regimes.
5. Examine how wall shear stress affects pressure drop and is used to compute the Darcy friction factor in pipe flows.

MODULE IV: Resistance of Immersed bodies & Particle Technology 12h [9L + 3T]

Motion from gravitational and Centrifugal fields - Terminal Settling velocity (Derivation of the equation using force balance is required), Stoke's law-Intermediate law - Newton's law – Hindered Settling. Flow through packed bed; Introduction, Derivation of Kozney Carman equation, Blake Plummer equation and Ergun equation. Fluidization: Introduction; types of fluidization and minimum fluidization velocity.

Particle technology – Describing the size of a single particle-Shape factor, mean diameter, Particle size analysis - Sieve analysis, common methods of displaying size distribution. Electrozone sensing, laser diffraction, Elutriation. Particle size reduction – Introduction of comminution theory and associated laws, Types of size reduction equipment, factors affecting choice of equipment.

Tutorial:

Problem Solving on Terminal Settling Velocity, Case studies on Packed beds, Real time applications of Particle technology.

Self-Study (18h):

1. Learn the difference between individual (free) settling and group (hindered) settling in concentrated suspensions.
2. Explore industrial uses like catalytic cracking, drying, and combustion using fluidized bed reactors.
3. Review how the Ergun equation is used in chemical reactors and filtration systems.
4. Virtual Lab Simulation: Particle Size Analysis using Sieve Analysis.
5. Explore crushers, grinders, and mills used for different materials and reduction ratios.

Textbooks

1. W. L. McCabe, J. C. Smith, and P. Harriott, *Unit Operations of Chemical Engineering*, 6th ed. New York, NY, USA: McGraw-Hill, 2001.
2. J. M. Coulson and J. F. Richardson, *Chemical Engineering: Particle Technology and Separation Processes*, 5th ed., vol. 2. Oxford, U.K.: Butterworth-Heinemann, 1999.

Reference books

1. C. J. Geankoplis, *Transport Processes and Separation Process Principles*, 5th ed. Boston, MA, USA: Pearson, 2015.

2. Y. A. Çengel and J. M. Cimbala, *Fluid Mechanics: Fundamentals and Applications*, 3rd ed. New York, NY, USA: McGraw-Hill Education.
3. E. Ortega-Rivas, *Unit Operations of Particulate Solids: Theory and Practice*. Boca Raton, FL, USA: CRC Press.
4. M. J. Rhodes, *Introduction to Particle Technology*, 2nd ed. Chichester, U.K.: John Wiley & Sons, 2008.
5. J. M. Coulson and J. F. Richardson, *Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer*, 5th ed., vol. 1. Oxford, U.K.: Butterworth-Heinemann, 1999.
6. R. H. Perry and D. W. Green, Eds., *Perry's Chemical Engineer's Handbook*, 7th ed. New York, NY, USA: McGraw-Hill, 1997.
7. C. M. Narayanan and B. C. Bhattacharya, *Mechanical Operations for Chemical Engineers: Incorporating Computer Aided Analysis*. New Delhi, India: Khanna Publishers.

NPTEL/SWAYAM Courses for reference:

1. NPTEL: Fluid Flow Operations
   https://onlinecourses.nptel.ac.in/noc22_ch03/preview
2. NPTEL: Fundamentals of Particle and Fluid Solid Processing
   https://onlinecourses.nptel.ac.in/noc19_ch29/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48 hours]
	MODULE 1 [12 hours]	
1.1	Definition of Fluid, continuum concept of fluid; Fluid Statics - Forces on fluids and hydrostatic equilibrium	1
1.2	Measurement of Pressure using different types of manometers. Forces on submerged bodies - Buoyancy, Stability of floating and submerged bodies. (Numerical problems)	3
1.3	Introduction to fluid flow- Ideal fluid, Flow of incompressible fluids, flow visualization using the concept of streamline.	2
1.4	Classification of flow - Steady and unsteady state flow, uniform and non-uniform flow, rotational and irrotational flow, velocity potential and stream function.	1
1.5	Newtonian and non- Newtonian fluids: Momentum flux and Newton's Law of Viscosity, Rheology of fluids.	2
1.6	Problem-solving on Properties of fluids, Numericals on Forces on Submerged bodies, Group Learning on Classification of fluid flow	3
	MODULE II [12 hours]	
2.1	Laminar and Turbulent flow - Reynold's Experiment	1

2.2	Equations of Change for isothermal systems - Equation of Continuity, Qualitative treatment of Equation of Motion – Navier-Stoke's Equation and Euler equation (derivations not required).	2
2.3	Flow in boundary layers: concept of types of drag and drag coefficient, Overview of boundary layer separation and wake formation.	2
2.4	Flow through pipe - Bernoulli Equation (derivation required), Correction factors in Bernoulli Equation, Pump work – Numerical problems.	3
2.5	Outline of pressure losses (Numerical problems not desired) in straight pipes and in fittings, concept of equivalent diameter.	1
2.6	Problem-solving on Reynold's number, Continuity equation, Bernoulli's equation.	3
MODULE III [12 hours]		
3.1	Introduction; flow of incompressible fluid in circular pipe; laminar flow for Newtonian fluid; Hagen-Poiseullie equation (Derivation required)	1
3.2	Shear stress and Velocity distribution in circular channel, energy consideration in pipe flow, relation between average and maximum velocity.	2
3.3	Introduction to turbulent flow in a pipe-Prandtl mixing length; Universal velocity distribution, Friction factor-Fanning and Darcy, Moody diagram.	2
3.4	Transportation and Metering of Fluids - Pumps- Reciprocating and Centrifugal pumps, Characteristics of centrifugal pumps - Priming, cavitation, NPSH, water hammer, loss of head and power in centrifugal pumps.	2
3.5	Flow measurement - Introduction; general equation for internal flow meters; Orifice meter, Venturimeter and Rotameter; Local velocity measurement: Pitot tube and Hot wire anemometer.	2
3.6	Problem Solving on Shear stress and Velocity distribution, Pump Selection, Parametric studies by simulating multiple flow rates.	3
MODULE IV [12 hours]		
4.1	Motion from gravitational and Centrifugal fields - Terminal Settling velocity (Derivation of the equation using force balance is required), Stoke's law-Intermediate law - Newton's law – Hindered Settling	2
4.2	Flow through packed bed; Introduction, Derivation of Kozney Carman equation, Blake Plummer equation and Ergun equation, Applications of packed beds.	3

4.3	Fluidization: Introduction; different types of fluidization; minimum fluidization velocity; governing equation.	2
4.4	Particle technology – Shape factor & Mean diameter, Particle size analysis - Sieve analysis, common methods of displaying size distribution. Electrozone sensing, Elutriation.	1
4.5	Particle size reduction - Theories of comminution, Types of size reduction equipment, factors affecting choice of equipment.	1
4.6	Problem Solving on Terminal Settling Velocity, Concept mapping on Flow through packed bed, Virtual labs on communition	3

CO Assessment Questions

CO-1

3-Mark Questions

1. Given a two-dimensional incompressible flow field with velocity components u(x,y)u(x, y)u(x,y) and v(x,y)v(x, y)v(x,y), determine whether a velocity potential ϕ and a stream function ψ exist. If they do, apply their definitions to calculate and interpret these functions for the given flow. **(Analyze)**
2. Compare ideal and real fluid with a scenario of water flowing through a pipe and air moving through a nozzle. **(Apply)**
3. A U-tube manometer is used to measure the pressure difference between two points in a pipe carrying water. If the manometer reading shows a height difference of 0.25 m with mercury (density = 13,600 kg/m^3) as the fluid, calculate the pressure difference between the two points in Pa. **(Analyze)**
4. Classify the following types of flow: water flowing through a pipeline at constant speed and air moving through a venturi meter with fluctuating velocity. Justify your answer by defining steady, unsteady, and uniform flow. **(Apply)**
5. Explain how the flow behavior of a non-Newtonian fluid, such as ketchup, differs from that of a Newtonian fluid when subjected to shear stress. Include the relationship between shear stress and shear rate. **(Apply)**

9-Mark Questions

1. Water flows through a pipe with a non-uniform cross-section. Discuss the conditions under which the flow could be considered steady, uniform, and incompressible. Explain how Reynolds number would help in determining whether the flow is laminar or turbulent. **(Analyze)**
2. Apply the U-tube manometer principle to calculate the pressure difference between two points in an industrial gas pipeline system. **(Apply)**

	3. Using a differential manometer, calculate the pressure difference in a vertical pipeline carrying oil, considering fluid density and height. **(Analyze)** 4. Determine the viscosity of a non-Newtonian fluid and calculate its flow behavior under shear stress using rheological principles. **(Apply)**
CO-2	**3-Mark Questions** 1. Apply boundary layer theory to analyze velocity distribution and flow separation over a flat plate in laminar flow. **(Apply/Analyze)** 2. Calculate the velocity at a narrower section of a pipe with constant flow rate using Continuity equation. **(Apply)** 3. Calculate the head loss due to friction in a pipe using Darcy-Weisbach equation and flow velocity values. **(Analyze)** 4. Classify flow as laminar or turbulent in a pipe based on observed flow characteristics by applying Reynold's number. **(Apply)** 5. Calculate velocity increase and pressure drop across a constriction in a fluid-carrying pipeline. **(Analyze)** **9-Mark Questions** 1. Exemplify the pipe flow with varying diameters and compute velocity changes for steady, incompressible flow conditions using the Continuity equation. **(Apply)** 2. Derive and apply expressions for shear stress and velocity distribution in laminar flow through a circular pipe. Establish the practical relationship between local and maximum velocity in internal pipe flow . **(Analyze)** 3. Derive Bernoulli's equation for real fluid flow, incorporating correction factors and applying it to practical pipe flow situations with assumptions stated. **(Apply)** 4. Compare and analyze the differential and cumulative methods of particle size analysis in terms of data interpretation, graphical representation, and application**. (Analyze)**

CO3	**3-Mark Questions** 1. Define and apply Sauter mean diameter, Martin's diameter, and Feret's diameter in particle size analysis, illustrating each with relevant sketches. **(Apply)** 2. Identify and explain six factors affecting size reduction, and apply their influence in selecting equipment for a specific material. **(Apply)** 3. Apply the concept of friction factor by explaining its types and using the Moody chart to analyze flow in pipes. **(Apply)** 4. Explain the practical applications of packed beds in industrial processes such as absorption, catalysis, and filtration, with relevant examples. **(Apply)** 5. Explain the principle of flow measurement using an orifice meter and apply it to derive the discharge expression, considering real fluid flow conditions. **(Apply)** **9-Mark Questions** 1. Derive the Ergun equation for pressure drop through a packed bed, starting from fundamental hydrodynamics, and apply it to analyze flow behavior, citing all assumptions used. **(Apply)** 2. Explain the different stages of fluidization with relevant sketches, and apply this knowledge to analyze fluidization behavior in industrial processes like chemical reactors. **(Apply)** 3. Explain the working principle of a fluid energy mill, applying it to size reduction processes, and illustrate with a detailed sketch. **(Apply)** 4. Elucidate the differential and cumulative methods of particle size analysis and apply them to interpret particle size distribution data for material characterization in industrial processes. **(Apply)** 5. Compare minimum fluidization velocity for five different particle types in a bubbling bed reactor. Propose how a fluidized bed could be adapted for biomass drying, and predict operational challenges based on particle behavior. **(Analyze)**
	3-Mark Questions 1. How would you choose between a Venturimeter and an Orificemeter for measuring fluid flow in an industrial pipeline, considering factors like accuracy, cost, and energy loss? **(Analyze)**

CO4	2. In what ways can knowledge of drag and drag coefficient be used to reduce energy consumption in transportation systems? **(Apply)** 3. How can electrozone sensing be effectively used to analyze particle size distribution in biomedical or pharmaceutical applications, and what makes it suitable for quality control? **(Analyze)** 4. In what ways can understanding and controlling cavitation improve the performance and longevity of pumps? **(Apply)** 5. Determine the terminal settling velocity during hindered settling to design an efficient solid-liquid separation system in industrial processes? **(Apply)** **9-Mark Questions** 1. Which factors would guide your choice between gravity settling and elutriation methods for particle size analysis in an industrial application? **(Apply)** 2. Explain by what means the comprehension of fluidization regime transitions and the calculation of the minimum fluidization velocity be utilized to optimize the operation and efficiency of fluidized bed systems in industrial applications? **(Analyze)** 3. Determine the terminal settling velocity of a spherical particle from the force balance equation, and how would you apply this understanding to design efficient sedimentation systems for industrial applications? **(Apply)** 4. Elucidate the application of laws of comminution and various methods of size reduction in industrial processes like mining and pharmaceuticals to improve material processing efficiency. **(Apply)** 5. Propose a particle separation process for recovering valuable metals from e-waste. Compare mechanical, hydrodynamic, and electrostatic separation methods, and propose a sustainable integrated strategy.**(Apply)**
Prepared by: Dr. Uma Krishnakumar, Asst. Professor, Department of Biotechnology Reviewed by: Dr. K Haribabu, Associate Professor, Dept. of Chemical Engg. , NIT Calicut	

24BTR404	CHEMICAL AND BIOLOGICAL REACTION ENGINEERING	L	T	P	R	C	Year of Introduction
		2	1	0	1	4	2024

Preamble:
The course provides a foundational and applied understanding of the principles that govern the rates of chemical and biological reactions and the design of reactors that facilitate these transformations. By applying these principles across different scales, the course bridges the gap between molecular-level reaction kinetics and large-scale reactor performance for both chemical and biochemical systems.

Prerequisite: Fundamentals of material and energy balances

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Apply the principles of chemical kinetics to describe the rates of chemical and biological reactions. **[Apply]**
CO 2	Analyze the performance of Batch and Continuous reactors and recommend modifications for improvement. **[Analyze]**
CO 3	Predict the conversion for ideal and non-ideal reactors. **[Apply]**
CO 4	Analyze and model microbial growth and bioreactor performance. **[Analyze]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	3							
CO2	3	3	3	2							
CO3	2	2	3	3							
CO4	3	3	3	2							

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate				
Create				

Assessment Pattern for Project Component

Bloom's Category	Continuous Assessment Tools		
	Evaluation 1	Evaluation 2	Report
Remember			

Understand			
Apply			
Analyze			
Evaluate			
Create	√	√	√

Mark Distribution of CIA

Course Structure [L-T-P-R]	**Theory [L]**				**Project[R]**			
	Attendance	**Assignment**	**Test-1**	**Test-2**	**Evaluation 1**	**Evaluation 2**	**Report**	**Total Marks**
2-1-0-1	5	5	7.5	7.5	10	10	5	50

Total Mark distribution

Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hours

End Semester Examination [ESE]: Pattern

PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 2	2 Questions from each module. Any full 6 Questions, each carrying 3 marks (6x3=18 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub-divisions. Each question carries 8 marks. Marks: (4x8 = 32 marks)	50

SYLLABUS

MODULE I: Kinetics of Homogeneous Reactions 9h [6L + 3T]

Overview of chemical and biological reaction engineering: Classification of chemical reactions, Definition of reaction rate, Variables affecting the rate of reaction. Concentration-dependent and Temperature-dependent terms of rate equation, Temperature dependency from Arrhenius law, Collision theory, and transition state theory (derivation not required). Interpretation of batch reactor data: Evaluation of rate equation by integral (first order irreversible and reversible, second order irreversible, series and parallel reactions only need to be addressed) and differential methods of analysis for constant volume and variable volume systems.

Tutorial:

Numerical Problems for evaluation of activation energy and determination of rate equations

based on integral method of analysis.

Self-Study(18h):

1. What are the key components of a biological reaction system?
2. What are the common applications of biological reaction engineering in environmental and industrial fields?
3. How do environmental factors such as pH, temperature, and substrate concentration affect biological reactions?
4. Study the intermediates used for developing mechanism for non- elementary reactions.
5. Develop mechanism for Hydrogen bromide formation reaction.

MODULE II: Introduction to reactor design 9h[6L + 3T]

Classification of reactors. Ideal reactors for a single reaction: Ideal batch reactor, Steady state mixed flow reactor, Steady state plug flow reactor. Design for single reactions: Size comparison of single reactors, Multiple reactor systems, Plug flow reactor in series and parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion.

Tutorial:

Numerical problems for evaluation of reactor volume, conversion etc.

Self-Study(18h):

1. Study industrial applications of batch, mixed flow and plug flow reactors.
2. Develop design equation for a recycle reactor.
3. Analyze and compare reactor design strategies for single reactions versus parallel reactions.

MODULE III:Non isothermal reactor design and Basics of non-ideal flow 10h[8L +2T]

Non isothermal reactor design: Heat effects in reactors, General graphical design procedure, Energy balance for batch, mixed flow and plug flow reactor. Optimum temperature progression.

Basics of non-ideal flow: Residence time distribution studies - C, E & F curves and their relationships. Conversion in non-ideal reactors, RTD in ideal reactors: Plug flow reactors, single CSTR

Tutorial:

Numerical problems on moments of RTD.

Self- Study(18h):

1. How temperature affects the heat of a reaction.
2. Develop RTD for laminar flow reactors.
3. How would you use RTD data to estimate conversion in a non-ideal reactor for a first-order reaction?

MODULE IV: Kinetics of cell growth and enzymes 8h[6L + 2T]

Kinetics of cell growth: substrate uptake and product formation in microbial growth, enzyme kinetics: Michaelis-Menten rate form, Determination of M-M parameters. Biological reactors – chemostats and plug flow tubular reactors, Immobilized cell systems and biofilm reactors. Monod chemostat model.

Tutorial:

Numerical problems for finding out the substrate and biomass concentrations.

Self-Study(18h):

1. Discuss the impact of oxygen limitation on microbial kinetics in aerobic processes.
2. State and explain the Michaelis-Menten equation. Under what conditions does it approximate first-order and zero-order kinetics?
3. Why is it important to determine M-M parameters in bioreactor design?
4. Derive the steady-state expressions for substrate and biomass concentrations in the Monod chemostat model.
5. How would you model the substrate concentration profile inside a biofilm?

Textbooks

1. O. Levenspiel, *Chemical Reaction Engineering*, 3rd ed. Hoboken, NJ, USA: John Wiley & Sons, 1999.
2. H. S. Fogler, *Elements of Chemical Reaction Engineering*, 5th ed. New Delhi, India: Prentice Hall of India, 2016.

Reference books

1. J. E. Bailey and D. F. Ollis, *Biochemical Engineering Fundamentals*, 2nd ed. New York, NY, USA: McGraw-Hill Chemical Engineering Series, 2017.
2. R. W. Missen, C. A. Mims, and B. A. Saville, *Introduction to Chemical Reaction Engineering and Kinetics*, 1st ed. Hoboken, NJ, USA: John Wiley & Sons, 1999.
3. C. G. Hill, *An Introduction to Chemical Engineering Kinetics & Reactor Design*, 1st ed. Hoboken, NJ, USA: John Wiley & Sons, 1977

NPTEL/SWAYAM Courses for reference:

1. NPTEL :: Chemical Reaction Engineering 1 (IIT Madras)
https://nptel.ac.in/courses/103106116

2. NPTEL :: Chemical Reaction Engineering 1 (IIT Guwahati)
https://archive.nptel.ac.in/courses/103/103/103103153/

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	Overview of chemical and biological reaction engineering: Classification of chemical reactions, Definition of reaction rate, Variables affecting the rate of reaction.	2

1.2	Concentration-dependent and Temperature-dependent terms of rate equation, Temperature dependency from Arrhenius law, Collision theory, and transition state theory.	1
1.3	Interpretation of batch reactor data: Evaluation of rate equation by integral (first order irreversible and reversible, second order irreversible, series and parallel reactions only need to be addressed) and differential methods of analysis for constant volume and variable volume systems.	3
1.4	Problem solving on evaluation of activation energy and determination of rate equations based on integral method of analysis -Tutorial	3
MODULE II [9 hours]		
2.1	Classification of reactors.	1
2.2	Ideal reactors for a single reaction: Ideal batch reactor, Steady state mixed flow reactor, Steady state plug flow reactor.	1
2.3	Design for single reactions: Size comparison of single reactors.	1
2.4	Multiple reactor systems, Plug flow reactor in series and parallel.	1
2.5	Mixed flow reactors of different sizes in series, determination of the best system for a given conversion.	2
2.6	Numerical problems for evaluation of reactor volume, conversion etc.- Tutorial	3
MODULE III [10 hours]		
3.1	Heat effects in reactors.	1
3.2	General graphical design procedure, Energy balance for batch, mixed flow and plug flow reactor. Optimum temperature progression.	2
3.3	Residence time distribution studies - C, E & F curves and their relationships.	2
3.4	Conversion in non-ideal reactors.	1
3.5	RTD in ideal reactors: Plug flow reactors, single CSTR.	2
3.6	Numerical problems on moments of RTD.- Tutorial	2
MODULE IV [8 hours]		
4.1	Kinetics of cell growth: substrate uptake and product formation in microbial growth.	2
4.2	Enzyme kinetics: Michaelis-Menten rate form, Determination of M-M parameters.	2
4.3	Biological reactors – chemostats and plug flow tubular reactors, Immobilized cell systems and biofilm reactors. Monod chemostat model.	2
4.4	Numerical problems for finding out the substrate and biomass concentrations. - Tutorial	2
PROJECT		
To engage students in the practical application of chemical and biological reaction engineering principles through a series of hands-on, project-based assignments. Students will work on		

analyzing reaction data, designing chemical and biochemical reactors, modeling reaction kinetics (both chemical and microbial), and optimizing reactor performance under varying operating conditions. Emphasis will be placed on integrating reaction engineering theory with computational tools and real-world chemical and bioprocess applications across industries such as pharmaceuticals, environmental engineering, and biofuels.

LESSON PLAN FOR PROJECT COMPONENT

No.	TOPIC	No. of Hours (12)
1	Preliminary Design of the Project	2
2	Zeroth presentation (4th week)	2
3	Project Work - First Phase	2
4	Interim Presentation	2
5	Project work - Final Phase & Report writing (discussions in class during project hours)	2
6	Final Evaluation, Presentation and Exhibition(11th and12th weeks)	2

CO Assessment Questions

CO-1

3-Mark Questions

1. Define 'rate of a reaction'. Which are the variables affecting the rate of a reaction? **(Understand)**
2. Differentiate between elementary and non- elementary reactions with suitable examples. **(Analyze)**
3. Explain the temperature dependent term of a rate equation. **(Understand)**
4. What are Arrhenius plots? What is its significance? **(Understand)**

8-Mark Questions

1. Distinguish between the methods available for analyzing the kinetics of chemical reactions. **(Analyze)**
2. Rate of a reaction between 'A' and 'B' becomes eight times when concentrations of both 'A' and 'B' are doubled. The rate is quadrupled when concentration of 'B' alone is doubled. Calculate the order w.r.t 'A' and 'B' separately and also the overall order. **(Apply)**
3. Develop the integral rate expression for a first order series reaction.**(Apply)**
4. Derive an integrated expression and half life time for an irreversible second order reaction having the rate equation 2A → Product. **(Apply)**

CO-2	**3-Mark Questions** 1. Recommend a reactor which is better for handling fast reactions. Also write the features and the applications of the same reactor. **(Apply)** 2. Differentiate between space time and holding time. **(Analyze)** 3. What is meant by an "Ideal reactor". What are the types? **(Understand)** 4. State the performance equation of a plug flow reactor? What does each term represent? **(Understand)** **8-Mark Questions** 1. "The larger the number of equal size mixed flow reactors in series, the closer should be the behaviour of the system approach plug flow". Justify the above statement. **(Analyze)** 2. A first-order irreversible reaction A→B is carried out in a plug flow reactor (PFR) at 350 K. The rate constant is k=0.2 $min^{-1.}$ If the feed concentration of A is 1 mol/L and a conversion of 80% is desired, calculate the volume of the PFR required for a feed flow rate of 2 L/min. **(Apply)** 3. In a batch reactor, a second-order irreversible reaction A→B occurs with a rate law $-rA=kCA^2$-, where k=0.5 L/mol. The initial concentration is CA0=2 mol/L How long will it take to reach 75% conversion? **(Apply)** 4. Presently 90% of reactant A is converted into product by a second order reaction in a single mixed flow reactor. We propose to use a second reactor similar to the one being used in series with it. For the same treatment rate as that used presently, find the effect of this addition of reactor on the conversion of reactant. **(Apply)**
	3-Mark Questions 1. What do you mean by 'Optimum temperature progression'? **(Understand)** 2. What is RTD? Briefly explain the methods available for measuring RTD? **(Understand)** 3. Draw the E curve and F curve of an ideal CSTR and label them. **(Understand)** 4. Define Damkohler Number. Give the expression for the same and explain its significance in reactor design? **(Understand)** **8-Mark Questions** 1. Derive the relation between heat of a reaction and temperature.

<table>
<tr>
<td>CO-3</td>
<td>
(Analyze)
2. Derive a relation between temperature and conversion both for adiabatic and non-adiabatic operations. (Analyze)
3. The concentration reading in the following table represents a continuous response to a pulse input into a closed vessel which is used as a chemical reactor. Calculate the mean residence time of fluid in the vessel and tabulate the exit age distribution. (Apply)
<table>
<tr><td>Time, min</td><td>0</td><td>5</td><td>10</td><td>15</td><td>20</td><td>25</td><td>30</td><td>35</td></tr>
<tr><td>Cpulse,g/l</td><td>0</td><td>3</td><td>5</td><td>5</td><td>4</td><td>2</td><td>1</td><td>0</td></tr>
</table>
4. Write the energy balance equation for a flow reactor and show that the adiabatic operating line of a flow reactor is linear in nature. (Analyze)
</td>
</tr>
<tr>
<td>CO-4</td>
<td>
3-Mark Questions
1. What do you mean by Wash out condition in a bioreactor? (Understand)
2. What are biological reactors? (Understand)
3. Explain the evaluation of Monod Kinetic parameters. (Understand)
4. Obtain the condition for cell wash out in a chemostat? (Apply)

8-Mark Questions
1. Derive a best known model of enzyme kinetics. (Apply)
2. Starting from fundamentals derive the Monod-Chemostat model. Schematically represent the substrate and biomass concentration and locate the wash out point. (Apply)
3. With the help of a neat diagram describe the batch growth kinetics? Clearly specify the growth rates in each phase? (Analyze)
4. Staring from the material balance equation derive the equation for substrate utilisation and product formation of an enzymatic reaction. (Apply)
</td>
</tr>
<tr>
<td colspan="2">Prepared by: Ms. Salini P J, Asst. Professor, Department of Biotechnology
Reviewed by: Mr Siby T P Senior Manager, BPCL Kochi</td>
</tr>
</table>

24BTL406	INSTRUMENTAL METHODS OF ANALYSIS LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble:
This laboratory course introduces modern analytical techniques used in biotechnology, pharmaceuticals, food safety, and environmental research. Students will gain hands-on experience with advanced methodologies such as spectroscopy, chromatography, electrophoresis, and molecular techniques, preparing students for pursuing careers in Biotech, R&D, biopharmaceuticals, and regulatory compliance.

Prerequisite: Fundamental knowledge in principles of chemistry, physics, mathematics and fundamental lab practices and safety protocols.

Course Outcomes: After the completion of course the student will be able to

CO1	Capability to perform and develop knowledge for the appropriate selection of instruments for the successful analysis of biomolecules. [Analyze]
CO2	Critically evaluate the strengths and limitations of the individual analytical techniques with respect to selectivity and sensitivity for solving bioengineering problems. [Analyze & Evaluate]
CO3	Possess and be capable of applying a knowledge of modern analytical technique. [Apply]
CO4	Apply the knowledge and skills acquired to analyze and interpret experimental data obtained from different instrumental measurements and communicate results effectively. [Apply]

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	2	2	3		2		3	3		
CO2	2	2	2	3		2		3	3		
CO3		2	2	3	3	2		3	3		
CO4		2	2	3		2		3	3		

Assessment Pattern

Bloom's Category	Continuous Assessment Tools	
	Classwork	Test1
Remember		
Understand	√	√
Apply	√	√
Analyse	√	√
Evaluate	√	
Create	√	

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks

0-0-3-0	5	25	20	50

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2 hrs

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:
(a) Procedure/Preliminary Work/Design/Algorithm (10 Marks)
(b) Conduct of Experiment/Execution of Work/Programming (15 Marks)
(c) Result with Valid Inference/Quality of Output (10 Marks)
(d) Viva Voce (10 Marks)
(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

1. Spectroscopic Techniques
2. UV-Visible Spectroscopy - Beer-Lambert's Law, Protein & Nucleic Acid Quantification.
3. Chromatographic Techniques
4. Thin Layer Chromatography (TLC) for Lipid Profiling - Separate fatty acids from biological samples
5. Paper Chromatography - For separation and identification of amino acids
6. Separation and identification of nucleic acids on gel electrophoresis
7. SDS PAGE - Separation & analysis of protein
8. Western Blot Analysis - Protein identification using immunodetection
9. Column Chromatography
10. Gel filtration Chromatography - Separation of protein and bioactive compounds on the basis of size
11. Affinity Chromatography for protein purification
12. Amplification of region of interest of DNA by Polymerase Chain Reaction

Self-Study (24h):

1. Detection of pesticide residues in food
2. Identification of adulteration in pharmaceutical drugs
3. AI -Assisted Data Interpretation of Chromatographic peaks - Using Python-based tool
4. Designing a Biosensor Prototype for Disease detection

Text books

1. D. A. Skoog, D. M. West, and F. J. Holler, *Fundamentals of Analytical Chemistry*. Boston, MA, USA: Cengage Learning.
2. K. W. Boehm, *Handbook of Bioanalytics: Analytical Techniques for Life Sciences*. Cham, Switzerland: Springer, 2022.
3. M. F. Vitha, *Chromatography: Principles and Instrumentation*. Hoboken, NJ, USA: Wiley, 2016.

LIST OF EXPERIMENTS	
No.	**Experiments**
1.	Spectroscopic Techniques
2.	UV spectra of Nucleic acids & Proteins in spectrophotometer
3.	Estimation of concentration of DNA and its purity
4.	Extraction and detection of Plant Pigments (Chlorophyll, Carotenoids)
5.	Chromatographic Techniques
6.	Separation of amino acids by Paper Chromatography & determination of Rf value
7.	Characterization of lipids by Thin Layer Chromatography (TLC)
8.	Separation of biomolecules by Gel filtration Chromatography
9.	Isolation and separation of bioactive compounds from plant extracts using gel filtration chromatography
10.	Separation of DNA using gel electrophoresis
11.	Separation & analysis of protein by SDS PAGE
12.	Protein identification using Western Blot Analysis
13.	Affinity Chromatography for protein purification
14.	Polymerase Chain Reaction
**A minimum of 10 experiments must be performed.*	

CO Assessment Questions	
CO1	1. How do you determine the most suitable analytical technique for the characterization of a novel protein? **(Analyze)** 2. Compare the selection criteria for spectroscopy vs. chromatography in the analysis of nucleic acids? **(Analyze)**
CO2	1. Discuss the advantages and drawbacks of affinity chromatography in protein purification compared to gel filtration chromatography? **(Analyze)** 2. Elucidate the concentration of nucleic acids, protein sample using absorption spectroscopy principles? **(Analyze)**
CO3	1. How can AI and machine learning improve chromatographic data interpretation and peak detection in HPLC analysis? **(Analyze)** 2. Explain the role of biosensors in real-time monitoring of environmental pollutants and biopharmaceutical quality control? **(Apply)**
CO4	1. How can statistical tools be used to validate the accuracy and reproducibility of SDS-PAGE protein separation results? **(Analyze)** 2. Design a data visualization report for spectrophotometric analysis comparing absorbance profiles of two different biomolecules. **(Analyze)**
Prepared by: Ms. Steny Mary Anto, Asst. Professor, Department of Biotechnology	

24BTL407	FLUID FLOW AND PARTICLE TECHNOLOGY LAB	L	T	P	R	C	Year of Introduction
		0	0	3	0	2	2024

Preamble:
Focuses on understanding and applying the principles of fluid mechanics and particle dynamics to analyze, design, and optimize various processes involving fluid flow, particulate materials, and their interactions in industrial applications.

Prerequisite: A basic understanding of engineering mathematics, physics, and introductory thermodynamics.

Course Outcomes: After the completion of course the student will be able to

CO1	Develop a comprehensive understanding of the fundamental principles of fluid flow, including laminar and turbulent flow regimes.**[Apply]**
CO2	Apply the conservation laws of mass, momentum, and energy to analyze fluid systems.**[Apply]**
CO3	Analyze and interpret experimental data to optimize fluid flow and particle separation processes in industrial applications.**[Analyze]**
CO4	Apply knowledge of particle mechanics to analyze and measure the behavior of particles in various fluid systems.**[Apply]**

CO - PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3							3	3	
CO2	3	3		3					3	3	
CO3		3		3	3				3	3	
CO4	3	3		3					3	3	

Assessment Pattern

Bloom's Category	Continuous Assessment Tools	
	Classwork	**Test1**
Remember		
Understand	√	√
Apply	√	√
Analyse	√	√
Evaluate	√	
Create	√	

Mark Distribution of CIA

Course Structure [L-T-P-R]	Attendance	Classwork	Lab Exam	Total Marks
0-0-3-0	5	25	20	50

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	50	50	2 hours

End Semester Examination Pattern:

The following guidelines should be followed regarding award of marks:

(a) Procedure/Preliminary Work/Design/Algorithm (10 Marks)

(b) Conduct of Experiment/Execution of Work/Programming (15 Marks)

(c) Result with Valid Inference/Quality of Output (10 Marks)

(d) Viva Voce (10 Marks)

(e) Record (5 Marks)

SYLLABUS- DETAILS OF EXPERIMENTS

Safety precautions and protocols in Lab, Basic First Aid knowledge and awareness of different types of hazards in laboratories

- Laboratory safety involves following strict protocols such as wearing personal protective equipment, properly handling chemicals, and being aware of emergency procedures to prevent accidents.

Determination of drag coefficient and verification of Stoke's law

- It involves experimentally measuring the terminal velocity of a sphere falling through a viscous fluid to confirm that the drag force is proportional to the velocity, as predicted by Stokes' law.

Particle size analysis by Sieve analysis

- Sieve analysis is a method used to determine the particle size distribution of granular materials by passing them through a stack of sieves with progressively smaller mesh sizes. The weight of material retained on each sieve is measured to assess the proportion of particles within specific size ranges.

Estimation of pressure drop for flow through fluidized bed

- The estimation of pressure drop for flow through a fluidized bed involves measuring the pressure difference across the bed as fluid flows upward, helping to determine the point at which particles become suspended and fluidization begins.

Determination of venturi coefficient

- The determination of the Venturi coefficient involves measuring the flow rate and pressure drop through a Venturi meter to evaluate the discharge coefficient, which accounts for energy losses and deviations from ideal flow behavior.

Measurement of Viscosity of Process Fluids Using Viscometers

- The measurement of viscosity of process fluids using viscometers involves determining a fluid's resistance to flow by observing its behavior under controlled conditions, typically using instruments like capillary, rotational, or falling ball viscometers.

Sub sieve particle size analysis using Pipette Analysis

- Sub-sieve particle size analysis using pipette analysis involves determining the size distribution of fine particles (typically smaller than 75 microns) in a suspension by allowing them to settle in a fluid and extracting samples at specific depths and times based on Stokes' law.

Sub sieve particle size analysis using Beaker decantation

- Sub-sieve particle size analysis using beaker decantation involves allowing fine particles suspended in a liquid to settle over time, then carefully decanting the supernatant at specific intervals to separate particles based on their settling rates and estimate their size distribution.

Calibration of Rotameter for liquid flow measurement

- Calibration of a rotameter for liquid flow measurement involves comparing the rotameter's readings with known flow rates under controlled conditions to establish an accurate relationship between float position and actual flow rate.

Reynold's Experiment

- The Reynolds experiment demonstrates the transition between laminar and turbulent flow by observing the behavior of a dye streak in a fluid flowing through a transparent tube, helping to determine the critical Reynolds number at which flow becomes unstable and turbulent.

Study of measurement of pressure

- The study of measurement of pressure involves understanding and using various instruments, such as manometers, Bourdon gauges, and pressure transducers, to accurately determine the force exerted by a fluid per unit area in different systems and conditions.

Study of the performance of a given Cyclone Separator

- The study of the performance of a given cyclone separator involves analyzing its efficiency in separating particles from a gas stream by measuring parameters like pressure drop, particle collection efficiency, and flow characteristics.

Study of size reduction equipment

- The study of size reduction equipment involves examining the operation and effectiveness of machines like crushers, grinders, and mills in reducing the particle size of solids to achieve desired material specifications.

Boundary layer flow over a flat plate

- Boundary layer flow over a flat plate refers to the thin region of fluid near the plate's surface where viscous forces cause the fluid velocity to gradually change from zero at the surface (due to the no-slip condition) to the free stream velocity, significantly affecting heat transfer and drag characteristics.

Self-Study (24h):

1. Key concepts, definitions and practical applications of fluids.
2. Fluid statics and fluid dynamics.
3. Flow in Open Channels and Compressible Flow (Advanced)
4. Real time applications of fluid machinery
5. Storage and flow of bulk solids
6. Virtual Lab Simulation Activity – Fluid Flow through Pipes
7. Virtual Lab Simulation: Particle Size Analysis using Sieve Analysis.

Text books

1. W. L. McCabe, J. C. Smith, and P. Harriott, *Unit Operations of Chemical Engineering*, 6th ed. New York, NY, USA: McGraw-Hill, 2000.
2. M. J. Rhodes, *Introduction to Particle Technology*, 2nd ed. Chichester, U.K.: John Wiley & Sons, 2008.
3. J. M. Coulson and J. F. Richardson, *Chemical Engineering: Fluid Flow, Heat Transfer and Mass Transfer*, 5th ed., vol. 1. Oxford, U.K.: Butterworth-Heinemann, 1999.
4. J. M. Coulson and J. F. Richardson, *Chemical Engineering: Particle Technology and Separation Processes*, 5th ed., vol. 2. Oxford, U.K.: Butterworth-Heinemann, 1999.
5. R. H. Perry and D. W. Green, Eds., *Perry's Chemical Engineer's Handbook*, 7th ed. New York, NY, USA: McGraw-Hill, 1997.

LIST OF EXPERIMENTS

No.	Experiments
1.	Determination of drag coefficient and verification of Stoke's law
2.	Particle size analysis by Sieve analysis
3.	Estimation of pressure drop for flow through fluidized bed
4.	Determination of venturi coefficient
5.	Measurement of Viscosity of Process Fluids Using Viscometers
6.	Sub sieve particle size analysis using Pipette Analysis.
7.	Sub sieve particle size analysis using Beaker decantation
8.	Calibration of Rotameter for liquid flow measurement
9.	Reynold's Experiment
10.	Study of measurement of pressure
11.	Study of the performance of a given Cyclone Separator
12.	Study of size reduction equipment
13.	Boundary layer flow over a flat plate

**A minimum of 10 experiments must be performed.*

CO Assessment Questions

CO1	1. Based on your experimental observations, at what flow conditions did you observe the transition from laminar to turbulent flow? How did you confirm this? 2. Measure and record the pressure drop across the pipe section at different flow rates, then analyze how it changes with flow regime. 3. Demonstrate how to visualize the flow pattern using dye or tracer particles in the flow channel. 4. Outline the method to plot velocity profiles across a pipe cross-section for different flow regimes.
CO2	1. Perform the experimental method to verify Bernoulli's theorem using a venturi meter or orifice meter, including how to measure pressure heads and flow velocity. 2. What measurements are required and how will you record data to verify the mechanical energy balance in a flowing fluid system? 3. Perform the experiment to determine the discharge coefficient of a flow meter, and how does it relate to conservation of energy? 4. Measure and analyze velocity profiles across a pipe cross-section to verify flow characteristics and conservation principles.
CO3	1. Perform and analyze data from sieve analysis or pipette analysis to assess particle size distribution. 2. Execute the steps to experimentally determine pressure drop across a fluidized bed and interpret its significance for system optimization. 3. Outline the method to prepare a detailed lab report interpreting experimental results for optimizing industrial fluid flow and particle separation processes. 4. Carry out the experiment to verify Stoke's law and its application in optimizing particle separation.
CO4	1. Perform and analyze the forces acting on a particle suspended in a fluid and how they affect particle motion. 2. Carry out the experimental methods used to measure settling velocity of particles in fluids. 3. Perform the experiment to determine particle size distribution using pipette analysis or sieve analysis. 4. Outline how to prepare a lab report analyzing particle mechanics data obtained from fluid system experiments.
Prepared by: Dr. Uma Krishnakumar, Asst. Professor, Department of Biotechnology Reviewed by: Dr. K Haribabu, Associate Professor, Dept. of Chemical Engg. , NIT Calicut and Mr. Vinay Prathap, Bioprocess Data Scientist, Sartorius, Bangalore	

24PWT208	UHV-II, LIFE SKILLS AND COMMUNITY WORK	L	T	P	R	C	Year of Introduction
		1	0	0	0	1	2024

Preamble:
This course aims to foster holistic development by integrating Universal Human Values (UHV II), essential life skills, and community engagement. Through self-reflection, discussion, and experiential learning, students will develop ethical awareness, emotional intelligence, and a sense of social responsibility. The course encourages active citizenship by engaging students in real-life community work, enabling them to apply values and skills for societal transformation.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Demonstrate an understanding of harmony in the self, family, society, nature, and existence by applying the principles of universal human values to reflect on ethical living, responsible relationships, ecological balance, and professional conduct. **[Evaluate]**
CO 2	Apply principles of emotional intelligence, effective communication, and critical thinking to personal and professional contexts, and demonstrate the ability to manage time, solve problems, and interact empathetically and assertively. **[Apply]**
CO 3	Demonstrate leadership, teamwork, and social responsibility by planning and implementing community-based initiatives that integrate human values, sustainable development principles, and participatory approaches, and critically reflect on their societal impact. **[Evaluate]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2				3	3	3		2	
CO2	2	3	2	2				3	3	3	2
CO3		3	3	2	2	3	3	3	3	3	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			Field Work
	Test1	Test 2	Assignment	
Remember	√	√		
Understand	√	√	√	
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	√
Create				√

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L]					
	Attendance	Assignment/Activity	Test - 1	Test - 2	Field Work	Total Marks
1-0-0-0	5	20	12.5	12.5	50	100

The assignments shall be evaluated as part of the activities under Modules 1, 2, and 3. Field work shall constitute the self-study component of Module 4.

SYLLABUS

MODULE I: Understanding the Self, Relationships, and Society [3h]

Session 1: Course Introduction and Self-Exploration (1h)

Course Purpose & Motivation, Recap of UHV-I, What is Self-Exploration?, Natural Acceptance & Experiential Validation, Human Aspirations: Continuous Happiness & Prosperity

Activities:

- *Reflection Exercise:* "Who am I?" – Write 5 statements about self and categorize as physical/sentient
- *Group Discussion:* Share experiences validating a value (e.g., truthfulness) through personal observation

Session 2: Understanding the Human Being and Prosperity (1h)

Co-existence of 'I' and Body, Needs of 'Self' vs 'Body', Body as Instrument of 'I', Sanyam (self-regulation) & Health, True Prosperity vs Accumulation

Activities:

- *Case Study:* "A Day in My Life" – Identify physical vs happiness-based needs
- *Role Play:* "Balanced Lifestyle vs Overconsumption"

Session 3: Harmony in Relationships and Society (1h)

Justice in Human Relationships, Trust vs Competence, Respect vs Differentiation, Visualizing Undivided Society, Universal Order, Gratitude in Relationships

Activities:

- *Circle Discussion:* Role of gratitude in student-teacher relationships
- *Scenario Analysis:* Interpersonal conflict – analyze based on values of trust and respect

Exercise: Map your relationship network and reflect on mutual happiness

MODULE II: Harmony with Nature and Professional Ethics [3h]

Session 1: Harmony in Nature and Existence (1h)

Harmony in Nature: Four Orders, Mutual Fulfilment, Recyclability, Self-regulation, Existence as Co-existence, Holistic Perception of Harmony

Activities:

- *Film Screening & Discussion:* "Home" – Reflection on human impact on environment
- *Group Task:* Trace a natural cycle (e.g., water or carbon) and discuss its harmony

Session 2: Human Values and Professional Ethics (1h)

Ethical Human Conduct: Definitiveness & Natural Acceptance, Professional Competence & Responsibility, Humanistic Education, Constitution, and Universal Order

Activities:

- *Debate:* "Technology – Boon or Bane for Nature?"
- *Reflective Writing:* "What does it mean to be an ethical engineer?"

Session 3: Path to Universal Human Order (1h)

Transition Strategy: Individual & Societal Level, People- & Eco-friendly Systems, Case Studies of Holistic Models

Activities:

- *Case Study Discussion:* Amul Cooperative Model / Barefoot College
- *Action Plan Activity:* Create a personal code of ethics and action plan as a future professional

MODULE III: Life Skills for Personal and Professional Growth [3h]

Emotional intelligence: Self-regulation, empathy, Communication: Listening, assertiveness, empathy-based interaction; Problem-solving, decision-making, and critical thinking, Time management, goal setting, and personal productivity

Activity 1: Empathy Circle – "Walking in Their Shoes"

Objective: To practice empathetic listening and perspective-taking.

Instructions:

- Students form groups of 4–5.
- Each member shares a brief real-life or imagined story involving emotional difficulty or a moral dilemma (max. 3 mins).
- Other members respond with only empathetic reflections (no advice or judgment).
- Debrief as a class: How does it feel to be truly heard? What makes listening difficult?

Activity 2: Communication Styles Role-Play
Objective: To differentiate between passive, aggressive, and assertive communication.

Instructions:

- In pairs or small groups, students enact 3 short scenarios (e.g., refusing extra work, asking for help, handling group conflict) using each style.
- Each group presents one version to the class, followed by reflection:
  - What was the impact of each style?
  - When is assertiveness most effective?

Activity 3: Critical Thinking Puzzle – "What's the Real Problem?"
Objective: To strengthen problem-identification and decision-making skills.

Instructions:

- Present a real-world case (e.g., project failure, peer conflict, missed deadline).
- In groups, students:
  - Identify the root cause(s),
  - Propose at least two solutions,
  - Discuss possible consequences.
- Each group shares findings with the class.

Activity 4: Time Audit and Productivity Planning
Objective: To improve time management through self-awareness and planning.

Instructions:

- Students reflect on and write down how they spent the previous day (hour by hour).
- Identify time wasters and productivity blocks.
- Using the SMART method, each student sets 1 academic and 1 personal goal with an action plan.

Activity 5: Emotional Regulation Check-In
Objective: To raise awareness of emotional triggers and calming strategies.

Instructions:

- Students list 3 situations that trigger frustration or anxiety.
- For each, they note:
  - Physical/emotional reactions,
  - Current coping strategies,
  - One new strategy (e.g., deep breathing, journaling, re-framing thoughts).

- Optionally, share coping ideas in small groups.

(Any three activities to be completed)

MODULE IV: Community Engagement and Social Responsibility [5h]

Values, Leadership, and Social Responsibility: Leadership, initiative, and teamwork as personal and social values, Community service as a form of experiential value education, Civic sense and responsibilities of educated citizens

Gandhian Vision and Community Empowerment:Introduction to Gandhian concept of Village Republics, Rural self-sufficiency and non-violence in development, Institutional role in community upliftment

Tools for Sustainable Community Engagement: Importance of eco-friendly, decentralized development, Science and technology for rural empowerment, Participatory planning, implementation, and monitoring, Knowledge, fund, and stakeholder convergence in development

Application through Service Learning: Integrating learning from values and life skills into community work, Designing small student-led interventions, Reflecting on leadership, empathy, and impact

Self -Study/Field Work (16h):

Students will identify a local community need and engage in a minimum 16-hour field project (individually or in small teams) aligned with the values studied.

Examples:

- Environmental awareness campaign
- Literacy or peer mentoring program
- Senior care/home visits with structured reflection
- Water/energy conservation drive
- Organic Farming
- Artisans, Industries and Livelihood
- Basic Amenities

Textbooks

1. R. R. Gaur, R. Asthana, and G. P. Bagaria, *A Foundation Course in Human Values and Professional Ethics*, 2nd rev. ed. New Delhi, India: Excel Books, 2019. ISBN: 978-93-87034-47-1.
2. P. Kapoor, *Professional Ethics and Human Values*. New Delhi, India: Khanna Book Publishing, 2022.
3. D. Goleman, *Emotional Intelligence*. New Delhi, India: Bloomsbury Publishing India Private Limited, 1995.

4. B. K. Mitra, *Personality Development and Soft Skills*, 3rd ed. New Delhi, India: Oxford Univ. Press, 2019.
5. K. G. Balakrishnan, *Unnat Bharat Abhiyan: Transforming India through Village Empowerment*, 1st ed. New Delhi, India: Ministry of Education, Govt. of India, 2022.

Reference book

1. I.Illich, *Energy & Equity*. Worcester, U.K.: The Trinity Press, and New York, NY, USA: Harper Collins, 1974.
2. E. F. Schumacher, *Small is Beautiful: A Study of Economics as if People Mattered*. London, U.K.: Blond & Briggs, 1973.
3. S. R. Covey, *The 7 Habits of Highly Effective People*. New York, NY, USA: Free Press, 2004.
4. A. Kumar, *Youth and Social Transformation*. Jaipur, India: Rawat Publications, 2012.

NPTEL/SWAYAM Courses for reference:

1. Exploring human values: Visions of happiness of perfect Societies, Prof. A.K. Sharma, IIT Kanpur https://nptel.ac.in/courses/109104068
2. Developing Soft Skills and Personality, Prof. T. Ravichandran, IIT Kanpur https://onlinecourses.nptel.ac.in/noc22_hs77/preview
3. Corporate social responsibility, By Prof. Aradhna Malik, IIT Kharagpur, https://onlinecourses.nptel.ac.in/noc21_mg54/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [14 hours]
	MODULE I [3 hours]	
1.1	Course Introduction and Self-Exploration	1
1.2	Understanding the Human Being and Prosperity	1
1.3	Harmony in Relationships and Society	1
	MODULE II [3 hours]	
2.1	Harmony in Nature and Existence	1
2.2	Human Values and Professional Ethics	1
2.3	Path to Universal Human Order	1
	MODULE III [3 hours]	
3.1	Emotional intelligence	1
3.2	Communication:	1
3.3	Problem-solving, decision-making, and critical thinking, Time management, goal setting, and personal productivity	1
	MODULE IV [5 hours]	
4.1	Values, Leadership, and Social Responsibility	1
4.2	Gandhian Vision and Community Empowerment:	1
4.3	Tools for Sustainable Community Engagement	1
4.4	Application through Service Learning	2

LESSON PLAN FOR FIELD WORK		
No.	**Topic**	**No. of Hours [16]**
1.	Orientation & Need Identification	1
2.	Proposal Submission:	1
3.	Field Implementation	9
4.	Reflection Session:	3
5.	Final Submission	2
No.	**Field Work Assessment**	**50 marks**
1.	Problem identification	5
2.	Planning and organization	5
3.	Execution and teamwork	15
4.	Reflection and learning outcomes	10
5.	Report and presentation	15

CO Assessment Questions	
CO-1	1. What is the meaning of natural acceptance? **(Understand)** 2. List the four levels of harmony discussed in the course. **(Remember)** 3. Explain the difference between prosperity and accumulation. **(Understand)** 4. How do trust and respect influence human relationships? **(Analyze)** 5. Apply the principle of Sanyam to your daily routine. What changes would you make? **(Apply)** 6. How can you promote harmony in your classroom or hostel? **(Apply)** 7. Analyze the current societal model in terms of human aspirations and values. **(Analyze)** 8. How does imbalance in nature reflect the lack of harmony at the human level? **(Analyze)**
CO-2	1. What are the key components of emotional intelligence, and why are they important in both personal and professional life? **(Understand)** 2. Explain the difference between assertive and aggressive communication. How can this distinction improve interpersonal relationships? **(Analyze)** 3. Describe a situation where you faced a communication challenge. How would you apply assertiveness and empathy to handle it differently now? **(Apply)** 4. Given a tight academic schedule and personal responsibilities, how would you apply time management techniques to maintain productivity and well-being? **(Apply)**

CO-3	1. What are the core values promoted through Gandhian principles of rural development? **(Understand)** 2. List the essential elements of participatory planning in a community project. **(Remember)** 3. Explain how eco-friendly, decentralized development contributes to rural sustainability. **(Understand)** 4. Describe the relationship between civic responsibility and community engagement for students. **(Analyze)** 5. How would you apply leadership and teamwork skills in organizing a community-based awareness campaign on environmental sustainability? **(Apply)** 6. Devise a plan to involve your peers in a service-learning activity that addresses a local issue. **(Apply)** 7. Analyze the roles of different stakeholders (educational institutions, local governance, NGOs) in the successful execution of community projects. **(Analyze)** 8. Compare two community interventions and identify the factors that led to the success or limitations of each. **(Analyze)**
Prepared by: Ms. Vini Valsan, Asst. Professor, Department of Applied Science & Humanities.	

PROGRAM ELECTIVE - 1

24BTE411	ENZYME ENGINEERING AND TECHNOLOGY	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:

The field of Enzyme Engineering and Technology empowers students to explore the structure, function, and modification of enzymes to enhance their performance and tailor them for specific applications. This course is designed to provide a strong foundation in enzyme kinetics, mechanisms, purification and applications. By undertaking this course, students will not only deepen their understanding of enzymology but also gain a critical perspective on the technological advancements shaping modern industrial biocatalysis. The knowledge and skills acquired here aim to prepare them for impactful careers in research, development, and innovation in diverse scientific and engineering domains.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Describe the structure, classification, and catalytic mechanisms of enzymes, and summarize the roles of cofactors, coenzymes, and non-protein catalysts. **[Understand]**
CO 2	Apply kinetic models to determine enzyme parameters and assess the effects of inhibitors and environmental factors on enzyme activity. **[Apply]**
CO 3	Analyze enzyme immobilization techniques and purification methods to evaluate enzyme performance in industrial bioreactors.**[Analyze]**
CO 4	Evaluate the industrial, medical, and environmental applications of enzymes with emphasis on sustainability and innovation.**[Evaluate]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2									
CO2	3	3	2	2							
CO3	3	3	3	2							
CO4	3	2	3		3	3					

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate				
Create				

Mark Distribution of CIA

Course Structure	Theory [L-T]	

[L-T-P-R]	Attendance	Assignment	Test-1	Test-2	Total Marks
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	50	50	2.5 hours

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Total Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Classification and Mechanism of Enzyme action [9h]

General introduction and historic background. Nomenclature and Classification of Enzymes. Structure of enzyme, Comparison between enzymes and chemical catalysts, Protein nature of enzymes and Non protein enzymes- Ribozymes, Abzymes and DNAzymes. Metalloenzymes and metal activated enzymes. Coenzymes and Cofactors. Mechanisms of enzyme action– concept of active site and energetics of enzyme-substrate complex formation, specificity of enzyme action. Isoenzymes, monomeric and oligomeric enzymes, multienzyme complex, holoenzyme, apo-enzyme, enzyme activity unit, turn over number and specific activity.

Self-Study (13h):

1. Role of IUBMB in Enzyme Nomenclature: Explore the role of the International Union of Biochemistry and Molecular Biology in standardizing enzyme names.
2. Case Study: Classification of Common Digestive Enzymes: Classify enzymes like amylase, pepsin, lipase, trypsin using EC system.
3. Case Study: Enzymes Dependent on Coenzymes in the TCA Cycle: Identify and understand coenzyme-dependent reactions in the citric acid cycle.
4. Clinical Significance of Coenzymes in Metabolic Disorders: Link deficiencies in coenzymes (like B12 or thiamine) to specific diseases.

MODULE II: Enzyme Kinetics [9h]

Lock and key model vs. induced fit model, Kinetics of single substrate reactions, estimation of

Michelis-Menten parameters, kinetic plots– multi-substrate reaction mechanisms. Kcat. Types of inhibition-kinetics models, allosteric regulation of enzymes. Factors affecting the enzyme activity- Substrate concentration, pH and temperature.

Self-Study (13h):

1. Comparison of Km and Vmax across different enzymes: Select 2–3 enzymes and compare their kinetic parameters to infer substrate affinity and catalytic potential.
2. Refer journal articles and plot LB plot using the experimental data.
3. Study the differences between allosteric and non-allosteric enzymes and also clinical significance of allosteric enzymes.
4. Determine how variation in temperature affect activity of salivary amylase.

MODULE III: Enzyme immobilization and purification [9h]

Enzyme immobilization methods – adsorption, matrix entrapment, encapsulation, cross linking, covalent binding, immobilized enzyme kinetics: effects of external mass transfer resistance. Operation of Bioreactors Using Immobilized Enzymes-Packed bed, fluidized bed, membrane reactors. Sources of enzymes (microbial, plant, animal), Methods of extraction, Methods of enzyme purification, criteria of purity.

Self- Study (14h):

1. Case Study: The Use of Immobilized Enzymes in Food and Beverage Industry: Research the role of immobilized enzymes in processes like brewing, dairy production, or enzyme-assisted flavour enhancement.
2. Recent Advances in Enzyme Immobilization Technologies: Investigate cutting-edge technologies in enzyme immobilization, including nanomaterials, novel supports, and multi-enzyme systems for improved catalytic efficiency.
3. Refer literature and find out different enzyme characterization methods employed. Study the principle of each method.
4. NPTEL lectures in Enzyme Sciences and Technology course.

MODULE IV: Industrial environmental and Clinical uses of Enzymes [9h]

Applications of enzymes in textile, leather, detergent, paper, confectionery, dairy industry, beverage and fruit processing, food processing and preservation. Environmental applications, Application of enzymes in medicine and analysis, Biosensors, component parts. Enzymes as thrombolytic agents, Anti-inflamatory agents, strptokinasae, asparaginase.

Self-Study (14h):

1. Research how enzyme-degradable plastics are being developed as a sustainable alternative to traditional food packaging.
2. Focus on cutting-edge applications such as enzyme-modified food products (eg., healthier versions of processed foods using enzymes to reduce fat or sugar content).
3. Research how enzyme-degradable plastics are being developed as a sustainable alternative to traditional food packaging.

4. Evaluate how elevated liver enzymes are used to detect liver disorders

Textbooks

1. T. Palmer, *Enzymes: Biochemistry, Biotechnology, Clinical Chemistry*, 2nd ed. New Delhi, India: Affiliated East-West Press Pvt. Ltd., 2008.
2. N. C. Price and L. Stevens, *Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins*, 3rd ed. Oxford, U.K.: Oxford Univ. Press, 1999.
3. M. F. Chaplin and C. Bucke, *Enzyme Technology*. Cambridge, U.K.: Cambridge Univ. Press, 1990.
4. N. K. Prasad, *Enzyme Technology: Pacemaker of Biotechnology*, 1st ed. New Delhi, India: PHI Learning Pvt. Ltd., 2013.

Reference books

1. K. Buchholz, V. Kasche, and U. T. Bornscheuer, *Biocatalysts and Enzyme Technology*, 2nd ed. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. KGaA, 2012.
2. H. Zhao, Ed., *Enzyme Engineering: Methods and Protocols*, Methods in Molecular Biology, vol. 388. Totowa, NJ, USA: Humana Press, 2007.
3. P. Bhatt, Ed., *Industrial Applications of Microbial Enzymes*, 1st ed. Boca Raton, FL, USA: CRC Press, 2023.
4. R. R. Singhania, A. K. Patel, H. A. Ruiz, and A. Pandey, Eds., *Biomass Hydrolyzing Enzymes: Basics, Advancements, and Applications*, 1st ed. Boca Raton, FL, USA: CRC Press, 2024.
5. S. M. Bhatt, *Enzymology and Enzyme Technology*, 1st ed. New Delhi, India: S. Chand Publishing, 2011.

NPTEL/SWAYAM Courses for reference:

1. NPTEL : Biotechnology - NOC:Enzyme Sciences and Technology

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	**Introduction to Enzymes**: General introduction and historic background. Nomenclature and Classification of Enzymes.	1
1.2	Structure of enzyme.	1
1.3	Comparison between enzymes and chemical catalysts.	1
1.4	Protein nature of enzymes and Non protein enzymes- Ribozymes, Abzymes and DNAzymes.	1
1.5	Metalloenzymes and metal activated enzymes. Coenzymes and Cofactors.	1
1.6	Mechanisms of enzyme action– concept of active site and energetics of enzyme-substrate complex formation.	1
1.7	Isoenzymes, monomeric and oligomeric enzymes, multienzyme	1

	complex.	
1.8	Holoenzyme apo-enzyme, enzyme activity unit.	1
1.9	Specificity of enzyme action	1
1.10	Turn over number and specific activity.	1
MODULE II [9 hours]		
2.1	Lock and key model vs. induced fit model.	1
2.2	Kinetics of single substrate reactions, estimation of Michelis-Menten parameters.	1
2.3	Kinetic plots– multi-substrate reaction mechanisms, Kcat.	2
2.4	Types of inhibition.	1
2.5	Kinetics models.	2
2.6	Allosteric regulation of enzymes.	1
2.7	Factors affecting the enzyme activity-Substrate concentration, pH and temperature.	1
MODULE III [9 hours]		
3.1	Enzyme immobilization methods – adsorption, matrix entrapment, encapsulation, cross linking, covalent binding.	2
3.2	Immobilized enzyme kinetics: effects of external mass transfer resistance.	1
3.3	Operation of Bioreactors Using Immobilized Enzymes-Packed bed.	1
3.4	Fluidized bed.	1
3.5	Membrane reactors.	1
3.6	Sources of enzymes (microbial, plant, animal)	1
3.7	Methods of extraction and purification.	1
3.8	Criteria of purity.	1
MODULE IV [9 hours]		
4.1	Applications of enzymes in textile, leather.	1
4.2	Detergent, paper, Confectionery.	1
4.3	Dairy industry, Beverage and fruit processing.	1
4.4	Food processing and preservation, Environmental applications.	1
4.5	Application of enzymes in medicine and analysis.	1
4.6	Biosensors, component parts.	1
4.7	Enzymes as thrombolytic agents.	1
4.8	Anti-inflamatory agents.	1
4.9	Streptokinase, Asparaginase.	1
CO Assessment Questions		

CO-1	1. Explain the classification of enzymes according to the Enzyme Commission (EC) system. **[Understand]** 2. Describe the difference between protein enzymes and non-protein enzymes such as ribozymes and abzymes. **[Understand]** 3. Illustrate how an enzyme's active site is involved in the formation of the enzyme-substrate complex**. [Apply]** 4. Evaluate the advantages and limitations of using enzymes versus chemical catalysts in industrial applications**. [Analyze]**
CO-2	1. Explain the difference between the lock and key model and the induced fit model of enzyme action. **[Understand]** 2. Define the term "Kcat" and explain how it is used to evaluate enzyme efficiency. **[Remember]** 3. Demonstrate the effect of a non-competitive inhibitor on the Michaelis-Menten plot and explain its impact on enzyme function. **[Apply]** 4. Analyze how enzyme inhibition models (competitive, non-competitive, uncompetitive) can be distinguished from each other using graphical methods. **[Analyze]**
CO-3	1. Describe the different methods of enzyme immobilization (adsorption, matrix entrapment, covalent binding) and their advantages and disadvantages. **[Understand]** 2. Explain the role of immobilization in enhancing enzyme stability and reusability in industrial applications. **[Understand]** 3. Demonstrate how external mass transfer resistance in immobilized enzymes could affect the overall efficiency of a bioreactor. **[Apply]** 4. List the common techniques used for enzyme purification and the criteria used to assess enzyme purity. **[Remember]**
CO-4	**1.** Describe the applications of enzymes in the textile and detergent industries and explain their benefits. **[Understand]** **2.** List some environmental applications of enzymes, such as bioremediation, and explain how they contribute to pollution control. **[Remember]** 3. Examine the impact of enzyme-based biosensors on medical diagnostics and compare them to traditional diagnostic techniques. **[Analyze]** 4. Summarize the role of enzymes in food processing and preservation, including examples such as lactase in dairy products. **[Understand]**
Prepared by: Dr. Ranimol G, Asst. Professor, Department of Biotechnology	

24BTE412	FOOD SAFETY AND QUALITY MANAGEMENT	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:

Food Safety and Quality Management is a critical discipline that ensures the protection of public health through the regulation, monitoring, and control of food production, processing, and distribution. In an era of globalized food supply chains, the assurance of safe and high-quality food has become increasingly complex and essential. This field integrates scientific principles, regulatory frameworks, and management systems to prevent foodborne illnesses, ensure compliance with national and international standards, and meet consumer expectations for safety, nutrition, and quality.

Prerequisite: Nil

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Explain the significance of food safety and identify potential hazards in food processing and storage. **[Apply & Analyze]**
CO 2	Interpret national and international food safety laws, standards, and labeling regulations. **[Apply]**
CO 3	Apply principles of quality management systems such as GMP and ISO standards in food production. **[Analyze]**
CO 4	Evaluate and design safety and quality assurance strategies using risk-based approaches and audit procedures. **[Apply]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	2	3				2					
CO2	2	3				3					
CO3	2	3	3			3	3			2	
CO4			3			3	3			2	

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]				
	Attendance	Assignment	Test-1	Test-2	Total Marks

3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	3 hours

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Total Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Introduction to Food Safety [9h]

Importance of food safety in public health, Sources and types of food hazards (biological, chemical, physical), Food spoilage and contamination, Foodborne diseases and outbreak investigation, Principles of food microbiology, Principles of food chemistry.

Self-Study (13h):

1. Nutritional aspects of food.
2. Research any two real-life foodborne illness outbreaks.
3. Watch the video on “Five Keys to Safer Food”and Summarize the key takeaways in a one-page note.
4. Conduct a small informal survey (with family/neighbors) on common food hygiene practices at home or local food outlets.identify gaps and suggest simple improvements.

MODULE II: Food Laws and Regulatory Framework [9h]

Indian food regulatory bodies: FSSAI, BIS, AGMARK, International standards: Codex Alimentarius, WTO-SPS/TBT Agreements, Food labeling and consumer protection laws, Food traceability and recall systems, Overview of food regulations in: US, EU & ASEAN countries

Self-Study (13h):

1. Debate on issues and limitations of current food laws and regulations.
2. Comparison of FSSAI, BIS, and AGMARK Certification Processes
3. Explore Codex Alimentarius Standards for a Specific Food Product
4. Analyze a Food Product Label from a Supermarket

Case Study: Food Recall Event in India or Abroad

MODULE III: Quality, Regulatory and Manufacturing Aspects [9h]

Total Quality Management (TQM) in food industry, Good Manufacturing Practices (GMP), Good Hygiene Practices (GHP), ISO 9001 and ISO 22000 standards, Definition of quality, Quality-prediction model based on quality kinetics and process state equations. Quality attributes of food and sensory evaluation, Role of instrumentation in quality control (e.g., spectrophotometry, HPLC, GC-MS, LC-MS).

Self –Study (14h):

1. Identify a real-life case study of a food company that successfully implemented TQM.
2. Conduct a small sensory comparison at home (e.g., two brands of juice or biscuits).
3. Read basic concepts of how quality kinetics (e.g., degradation rate of nutrients) and process state equations are used in shelf-life estimation and quality control.
4. Review FSSAI or WHO guidelines for both GMP and GHP.

MODULE IV: Risk Assessment and Safety Management Tools [9h]

Principles of risk analysis: risk assessment, risk management, risk communication, Hazard Analysis and Critical Control Points (HACCP) – principles and implementation, Food Safety Management Systems (FSMS), Food safety audits and documentation, Case studies on food safety failures and lessons learned.

Self-Study (14h):

1. Study how HACCP is implemented in a food manufacturing setting (e.g., dairy, bakery, meat processing).
2. Read FSSAI's role in conducting food risk assessments and setting safety standards.
3. Choose a well-documented food safety failure, Analyze;**a)** Root cause; **b)** How the failure could have been prevented; **c)** Lessons learned and regulatory responses.
4. Prepare a Risk Communication Plan (Mini Activity)
   - ➢ Imagine a food contamination event has occurred in a college canteen.
   - ➢ Outline a brief communication strategy to inform students, staff, and authorities clearly and responsibly.

Textbooks

1. Vasconcellos J., *Quality Assurance for the Food Industry: A Practical Approach*, 1st ed. Boca Raton, FL, USA: CRC Press, 2005.
2. R. P. Carpenter and D. H. Lyon, *Food Safety and Quality Assurance*, 2nd ed. Cham, Switzerland: Springer, 2000.
3. D. A. Shapton and N. F. Shapton, *Principles and Practices for the Safe Processing of Foods*, 1st ed. Oxford, U.K.: Butterworth-Heinemann, 2013.
4. P. L. Knechtges, *Food Safety: Theory and Practice*, 1st ed. Burlington, MA, USA: Jones & Bartlett Learning, 2011.

Reference books

1. Y. Motarjemi, *Food Safety Management: A Practical Guide for the Food Industry*, 1st ed. San Diego, CA, USA: Academic Press, 2013.
2. S. Mandal, *Principles and Practices for the Safe Processing of Foods*, 1st ed. New Delhi, India: New India Publishing Agency, 2011.
3. W. C. Frazier and D. C. Westoff, *Food Microbiology*, 5th ed. New York, NY, USA: McGraw-Hill Education, 2017.S. Mortimore and C. Wallace, *HACCP: A Practical Approach*, 3rd ed. Cham, Switzerland: Springer, 2013.
4. *FSSAI Manuals and Regulations*. [Online]. Available: https://www.fssai.gov.in

NPTEL/SWAYAM Courses for reference:

1. **Novel Technologies for Food Processing and Shelf-Life Extension**
   https://onlinecourses.nptel.ac.in/noc22_ag03/preview
2. **Food Safety and Quality Control**
   https://onlinecourses.swayam2.ac.in/cec20_ag06/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	Importance of food safety in public .	2
1.2	Sources and types of food hazards (biological, chemical, physical).	1
1.3	Food spoilage and contamination.	2
1.4	Foodborne diseases and outbreak investigation.	2
1.5	Principles of food microbiology.	1
1.6	Principles of food chemistry.	1
	MODULE II [9 hours]	
2.1	Indian food regulatory bodies: FSSAI, BIS, AGMARK.	2
2.2	International standards: Codex Alimentarius.	2
2.3	WTO-SPS/TBT Agreements.	2
2.4	Food labeling and consumer protection laws.	1
2.5	Food traceability and recall systems.	1
2.6	Overview of food regulations in: US,EU & ASEAN countries	1
	MODULE III [9 hours]	
3.1	Total Quality Management (TQM) in food industry, Good Manufacturing Practices (GMP).	2
3.2	Good Hygiene Practices (GHP), ISO 9001 and ISO 22000 standards.	2
3.3	Definition of quality, Quality-prediction model based on quality kinetics and process state equations.	2

3.4	Quality attributes of food and sensory evaluation.	1
3.5	Role of instrumentation in quality control (e.g., spectrophotometry, HPLC,).	2
MODULE IV [9 hours]		
4.1	Principles of risk analysis: risk assessment, risk management, risk communication.	3
4.2	Hazard Analysis and Critical Control Points (HACCP) – principles and implementation.	2
4.3	Food Safety Management Systems (FSMS)	1
4.4	Food safety audits and documentation.	1
4.5	Case studies on food safety failures and lessons learned.	2

CO Assessment Questions

CO-1	**3-Mark Questions** 1. Explain why food safety is important in public health.**(Understand)** 2. Given a scenario of a foodborne outbreak at a local restaurant, identify the possible sources of contamination. **(Apply)** 3. What steps are involved in investigating a foodborne disease outbreak?**(Understand)** 4. Describe the difference between food spoilage and food contamination.**(Analyze)** **9-Mark Questions** 1. Explain the significance of food safety in public health. Discuss how food safety failures can impact society using relevant examples.**(Understand)** 2. With examples, differentiate between biological, chemical, and physical hazards in food. How can these hazards be controlled in food processing environments? **(Analyze)** 3. Describe the common causes of food spoilage and contamination. Suggest preventive strategies used in the food industry to minimize spoilage.**(Understand & Apply)** 4. Explain how principles of food microbiology and food chemistry assist in identifying the source of contamination.**(Apply)**

CO-2	**3-Mark Questions** 1. How would you use food labeling regulations to assess whether a packaged food item complies with FSSAI guidelines? **(Analyze)** 2. Valuate the impact of WTO-SPS and TBT Agreements on India's food export sector. **(Evaluate)** 3. Explain the role of AGMARK in ensuring food quality.**(Understanding)** 4. How would you ensure compliance with FSSAI regulations while launching a new packaged food product in India? **(Apply)** **9-Mark Questions** 1. Explain the structure and functions of FSSAI. How does it coordinate with other Indian regulatory bodies like BIS and AGMARK to ensure food safety and quality?**(Understand)** 2. Compare and contrast the objectives of Codex Alimentarius with the WTO-SPS and TBT agreements. Why are these international frameworks important for global food trade and safety?**(Analyze)** 3. Discuss the essential components of food labeling regulations in India. How do these regulations help in consumer protection and informed decision-making?**(Apply)** 4. Explain the concept and importance of food traceability and recall systems. Illustrate with examples how these systems operate in either the US, EU, or ASEAN food regulatory framework.**(Apply)**
CO-3	**3-Mark Questions** 1. How would you apply the principles of Good Hygiene Practices (GHP) in a bakery production line? **(Apply)** 2. Evaluate the effectiveness of using spectrophotometry and HPLC for quality control in the food industry. **(Evaluate)** 3. Identify key principles of TQM and explain how they contribute to consistent food quality.**(Analyze)** 4. How do subjective (sensory) and objective (instrumental) methods contribute to assessing food quality?**(Apply)** **9-Mark Questions** 1. Explain the principles of Total Quality Management (TQM) in the food industry. How do GMP and GHP contribute to the implementation of TQM in food processing?**(Understand)** 2. Differentiate between ISO 9001 and ISO 22000 standards in the context of the food industry. Discuss how these systems support quality and food safety.**(Analyze)**

	3. Define food quality and explain various quality attributes used to assess food. How is sensory evaluation conducted and standardized to ensure product consistency?**(Understand & Evaluate)** 4. Describe the role of advanced instrumentation in food quality control. Explain how spectrophotometry, HPLC, and GC-MS are used in evaluating food products.**(Understand & Apply)**
CO-4	**3-Mark Questions** 1. Analyze a recent food safety failure case and identify where the breakdown occurred in risk communication or HACCP implementation. **(Analyze)** 2. Develop a food safety plan incorporating risk analysis and HACCP principles for a ready-to-eat food manufacturing unit. **(Create)** 3. Describe the purpose of food safety audits in food manufacturing.**(Understanding)** 4. Identify potential critical control points (CCPs) in a milk pasteurization process.**(Analyze)** **9-Mark Questions** 1. Explain the three components of risk analysis in food safety—risk assessment, risk management, and risk communication. How do they collectively contribute to effective food safety regulation?**(Apply & Analyze)** 2. Describe the principles of HACCP and outline the steps involved in its implementation. Why is HACCP considered a preventive approach rather than a corrective one in food safety management?**(Understand)** 3. What is a Food Safety Management System (FSMS)? Discuss how FSMS integrates documentation, audits, and verification to maintain safety throughout the food chain.**(Apply & Analyze)** 4. Choose a real or documented case study of a food safety failure. Analyze the causes, regulatory response, and lessons learned in the context of risk management and HACCP failure.(**Analyze)**
Prepared by: Ms. Marria C Cyriac, Asst. Professor, Department of Biotechnology Reviewed by: Mr. Sarath Menon, Grain Quality Inspector, Canada Grain Commission	

24BTE413	BIOENERGY AND BIOFUELS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
This course introduces students to sustainable energy solutions by exploring the principles, technologies, and applications of converting biological resources into renewable fuels and energy.

Prerequisite: A basic understanding of chemistry, biology, and thermodynamics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Apply the fundamental principles of biomass conversion to design basic processes for producing biofuels such as biodiesel, bioethanol, and biogas using different types of feedstocks. **[Apply]**
CO 2	Analyze the efficiency, cost-effectiveness, and environmental impact of various biofuel production technologies by comparing key performance parameters. **[Analyze]**
CO 3	Apply knowledge of microbial and enzymatic pathways to conduct or simulate laboratory-scale experiments for the production of second-generation biofuels. **[Apply/Design]**
CO 4	Analyze the influence of national and international bioenergy policies, regulations, and market dynamics on the development and adoption of biofuel technologies. **[Analyze/Design]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3		2	2		2					
CO2	3	3		2	2	3					2
CO3	3	2	2	2		3					2
CO4		2			2	3	2	2	2	2	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze		√	√	
Evaluate			√	
Create			√	

Mark Distribution of CIA

Course Structure	Theory [L-T]	

[L-T-P-R]	Attendance	Assignment	Test-1	Test-2	Total Marks
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution			
Total Marks	**CIA (Marks)**	**ESE (Marks)**	**ESE Duration**
100	40	60	2.5 hours

End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Total Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Fundamentals of Biorefinery [9h]

Fundamentals of Biorefinery- Principles of biorefinery, environmental aspects of biorefineries, Biorefinery products - biofuels such as ethanol, biodiesel, butanol, hydrogen, and biogas, biochemicals, and biopolymers. Policy issues in biofuels, Indian biofuel programme. Biorefinery feedstocks and their characteristics - sugars, starch, oil, microalgae, energy crops, lignocellulosic biomass, cost and availability of biorefinery feedstocks, pre-treatments of biomass.

Self-Study (13h):

1. Design a simplified flowchart of a biorefinery that processes a specific feedstock (e.g., lignocellulosic biomass) into multiple products like ethanol, biogas, and biopolymers.
2. Analyze and compare different biofuels in terms of feedstock, production method, energy content, and environmental impact.
3. Study and make a report on India's biofuel policy initiatives and implementation challenges.
4. Investigate different pretreatment techniques used for lignocellulosic biomass.
5. Identify and evaluate the biomass feedstocks available in your region.

MODULE II: Biorefinery types [9h]

Biorefinery types (based on platforms, products, feedstock, processes) and their features - C6 sugar platform biorefinery, Syngas platform biorefinery, C6 & C5 sugar and syngas platform biorefinery, SWOT analysis on a biorefinery, Life cycle analysis (LCA). Biochemical conversion, enzymes for biochemical conversion and their properties - cellulases, xylanases, amylases, lignin-degrading enzymes, Fermentation - Production of platform chemicals - Lactic acid and Polylactic acid, Succinic acid, Acetic, Butyric and Itaconic acids.

Self-Study (13h):

1. Understand and compare different types of biorefineries based on platform, feedstock, and process.
2. Analyze the strengths, weaknesses, opportunities, and threats of a real or hypothetical biorefinery.
3. Study the key enzymes used in biochemical conversion and summarize their roles.
4. Understand environmental implications of a biorefinery process using LCA.
5. Explore the microbial production of key platform chemicals and their derivatives.

MODULE III: Biomass Processing and Algal biorefineries [9h]

Thermochemical Processing of Biomass, General features of thermochemical conversion processes, Combustion, Pyrolysis, Gasification. Thermochemical Processing of Bio-Oil into Fuels, Methanol Production. Algae Biorefineries- basic principles, CO2 capture, biological kinetics and yields, algae cultivation, open pond cultivation, photobioreactors, algae harvesting and oil extraction, algae biodiesel production, heterogeneous catalysts for transesterification, Life Cycle Assessment of algae biorefineries and environmental implications, Economic analysis.

Self-Study (14h):

1. Understand the differences among combustion, pyrolysis, and gasification.
2. Study the processing steps to convert bio-oil (from pyrolysis) into usable fuels.
3. Visualize an integrated system that turns algae into biofuels and valuable co-products.
4. Evaluate the environmental sustainability of algae biodiesel production.
5. Compare algae growth systems and assess their practical feasibility.

MODULE IV: Global Biofuel Policy and Market Dynamics [9h]

National Bioenergy Policy Frameworks: Case studies: U.S. (RFS), Brazil (ethanol), India (ethanol blending), International Bioenergy Agreements and Coordination, Paris Agreement and renewable energy goals, IRENA, IEA Bioenergy, and global initiatives. Regulatory and Sustainability Standards: Lifecycle GHG assessments (LCAs), ILUC (Indirect Land Use Change), Certification schemes (ISCC, RSB, RED sustainability requirements), Environmental and Socioeconomic Considerations. Market Dynamics and Economic Drivers: Crude oil prices, fossil fuel subsidies, and competition, Future outlook for biofuels.

Self –Study (14h):

1. Analyze and compare the bioenergy policy frameworks of three key countries.
2. Understand how global institutions support and regulate bioenergy.
3. Explore the functioning and criteria of sustainability certification in biofuels.

4. Explore how market factors influence biofuel competitiveness.
   Study the environmental impact of biofuels beyond direct emissions.

Textbooks

1. Dahiya, Ed., *Bioenergy: Biomass to Biofuels*, 2nd ed. San Diego, CA, USA: Academic Press, 2019.
2. M. Drapcho, N. H. Pham, and T. H. Walker, *Biofuels Engineering Process Technology*. New York, NY, USA: McGraw-Hill, 2008.
3. V. C. Nelson, *Introduction to Bioenergy*. Boca Raton, FL, USA: CRC Press, 2010.
4. D. M. Mousdale, *Biofuels: Biotechnology, Chemistry, and Sustainable Development*. Boca Raton, FL, USA: CRC Press, 2010.

Reference books

1. J. Sadhukhan, K. S. Ng, and E. M. Hernandez, *Biorefineries and Chemical Processes: Design, Integration and Sustainability Analysis*. Hoboken, NJ, USA: John Wiley & Sons, 2013.
2. P. R. El-Halwagi, *Integrated Biorefineries: Design, Analysis, and Optimization*. Boca Raton, FL, USA: CRC Press, 2013.
3. C. Baskar, S. Baskar, and R. S. Dhillon, Eds., *Biomass Conversion: The Interface of Biotechnology, Chemistry and Materials Science*. Cham, Switzerland: Springer, 2012.
4. S.-T. Yang, H. El-Ensashy, and N. Thongchul, *Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers*. Hoboken, NJ, USA: John Wiley & Sons, 2013.
5. A. Pandey, R. Höfer, M. Taherzadeh, M. Nampoothiri, and C. Larroche, Eds., *Industrial Biorefineries & White Biotechnology*. Amsterdam, Netherlands: Elsevier, 2015.

NPTEL/SWAYAM Courses for reference:

1. NPTEL: Bioenergy
   https://onlinecourses.nptel.ac.in/noc19_bt16/preview

2. NPTEL: Biomass Conversion and Biorefinery
   https://onlinecourses.nptel.ac.in/noc22_ch28/preview

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	Fundamentals of Biorefinery- Principles of biorefinery, environmental aspects of biorefineries.	1
1.2	Biorefinery products - biofuels such as ethanol, biodiesel, butanol, hydrogen, and biogas, biochemicals, and biopolymers.	2
1.3	Policy issues in biofuels, Indian biofuel programme.	2
1.4	Biorefinery feedstocks and their characteristics - sugars, starch, oil.	1
1.5	Microalgae, energy crops, lignocellulosic biomass.	1

1.6	Cost and availability of biorefinery feedstocks, pre-treatments of biomass.	2
MODULE II [9 hours]		
2.1	Biorefinery types (based on platforms, products, feedstock, processes) and their features.	2
2.2	C6 sugar platform biorefinery, Syngas platform biorefinery, C6 & C5 sugar and syngas platform biorefinery	2
2.3	SWOT analysis on a biorefinery, Life cycle analysis (LCA)	1
2.4	Biochemical conversion, enzymes for biochemical conversion and their properties - cellulases, xylanases, amylases, lignin-degrading enzymes.	2
2.5	Fermentation - Production of platform chemicals - Lactic acid and Polylactic acid, Succinic acid, Acetic, Butyric and Itaconic acids.	2
MODULE III [9 hours]		
3.1	Thermochemical Processing of Biomass, General features of thermochemical conversion processes.	1
3.2	Combustion, Pyrolysis, Gasification. Thermochemical Processing of Bio-Oil into Fuels.	2
3.3	Methanol Production. Algae Biorefineries- basic principles, CO2 capture, biological kinetics and yields.	2
3.4	Algae cultivation, open pond cultivation, photobioreactors, algae harvesting and oil extraction.	2
3.5	Algae biodiesel production, heterogeneous catalysts for transesterification.	1
3.6	Life Cycle Assessment of algae biorefineries and environmental implications, Economic analysis.	1
MODULE IV [9 hours]		
4.1	National Bioenergy Policy Frameworks: Case studies: U.S. (RFS), Brazil (ethanol), India (ethanol blending)	2
4.2	International Bioenergy Agreements and Coordination, Paris Agreement and renewable energy goals.	1
4.3	IRENA, IEA Bioenergy, and global initiatives.	1
4.4	Regulatory and Sustainability Standards: Lifecycle GHG assessments (LCAs), ILUC (Indirect Land Use Change), Certification schemes (ISCC, RSB, RED sustainability requirements)	2
4.5	Environmental and Socioeconomic Considerations. Market Dynamics and Economic Drivers: Crude oil prices, fossil fuel subsidies, and competition.	2
4.6	Future outlook for biofuels.	1
CO Assessment Questions		

CO-1	**3-Mark Questions** 1. Explain how lignocellulosic biomass differs from sugar-based feedstock in bioethanol production.**(Apply)** 2. List three commonly used feedstocks for biogas production and explain why they are suitable. **(Apply)** 3. Draw a simple flow diagram of the process for converting corn into bioethanol. **(Apply)** 4. Identify and briefly describe the three main stages in anaerobic digestion for biogas production.**(Analyze)** 5. Compare the energy yields of biodiesel, bioethanol, and biogas when derived from the same amount of biomass.**(Analyze)** **9-Mark Questions** 1. Design a biogas production system for a rural farm using cattle dung as the primary feedstock. Explain the principles of anaerobic digestion, outline the design considerations, and describe how the produced biogas can be stored and utilized.**(Apply)** 2. Discuss the production of bioethanol from lignocellulosic biomass. Include the steps of pretreatment, hydrolysis, fermentation, and distillation. Evaluate the challenges involved at each stage and propose possible solutions. **(Apply)** 3. Design a process flow diagram for the production of biodiesel using waste cooking oil as a feedstock. Explain each step, including the chemical reaction involved, key parameters (e.g., temperature, catalyst), and by-products formed.**(Apply)** 4. Compare and contrast the biomass conversion routes (thermochemical vs. biochemical) used in the production of biodiesel, bioethanol, and biogas. Explain which route is suitable for different feedstocks and why. **(Apply)**
	3-Mark Questions 1. Compare the energy conversion efficiency of biodiesel and biogas production processes using agricultural waste as feedstock.**(Analyze)** 2. List two economic factors that affect the cost-effectiveness of bioethanol production and briefly explain their impact.**(Apply)** 3. State one major environmental benefit and one environmental drawback of using algae-based biodiesel.**(Apply)** 4. Which biofuel—bioethanol or biogas—has a lower carbon footprint per MJ of energy produced? Justify briefly.**(Analyze)** 5. Compare the land-use impacts of biodiesel production from soybeans and bioethanol from sugarcane.**(Analyze)**

CO-2	**9-Mark Questions** 1. Bioethanol can be produced from sugarcane or lignocellulosic biomass (e.g., agricultural residues). Analyze these two feedstocks by comparing: Conversion efficiency, Feedstock cost and availability and Environmental considerations (e.g., water usage, emissions). Which feedstock is more suitable for long-term bioethanol production? **(Analyze)** 2. Evaluate the use of algae as a feedstock for biodiesel production compared to conventional oil crops (e.g., soybean, rapeseed).**(Analyze)** 3. Compare the life cycle assessment (LCA) results for biodiesel and bioethanol derived from first-generation feedstocks.**(Analyze)** 4. A policymaker wants to choose between investing in community-level biogas plants or industrial-scale bioethanol plants. Perform a comparative analysis based on: Capital and operational cost, Community involvement and job creation and Environmental and waste management benefits. **(Analyze)**
CO-3	**3-Mark Questions** 1. Design a laboratory-scale experiment to hydrolyze rice straw using cellulase and hemicellulase enzymes.**(Apply/Design)** 2. Propose a suitable microorganism for fermenting xylose from lignocellulosic biomass. Justify your choice based on its enzymatic pathway.**(Apply)** 3. Select and justify a pretreatment method for wheat straw that enhances enzymatic hydrolysis efficiency. Suggest appropriate enzymes post-treatment and explain how they act on the biomass.**(Apply)** 4. Design a laboratory-scale fermentation process using engineered Escherichia coli to convert biomass-derived glucose into ethanol. Include key culture conditions and metabolic steps involved.**(Design)** 5. Describe the process conditions of enzymatic hydrolysis to suggest a protocol for converting rice husk into fermentable sugars using cellulase.**(Apply/Design)** **9-Mark Questions** 1. Design a complete laboratory-scale process for producing ethanol from corn stover. **(Apply/Design)** 2. Design a lab experiment to compare ethanol production efficiency between *Saccharomyces cerevisiae* and *Zymomonas mobilis* using glucose-rich hydrolysate. **(Apply/Design)** 3. Design an experiment comparing the efficiency of individual enzymes (cellulase, xylanase, β-glucosidase) in converting sugarcane bagasse into

	reducing sugars. **(Apply)** 4. Design a lab experiment for converting pretreated wheat straw into butanol using *Clostridium acetobutylicum.* **(Design)**
CO-4	**3-Mark Questions** 1. Compare the biofuel policy approaches of the European Union and the United States. How do differences in regulatory focus affect the adoption of advanced biofuel technologies? **(Analyze)** 2. Analyze how national bioenergy policies (such as India's National Bioenergy Mission or Ethanol Blending Program) influence the development and commercialization of second-generation biofuels. **(Analyze)** 3. How fluctuations in global crude oil prices affect the market adoption of biofuel technologies? **(Apply)** 4. Identify and analyze two regulatory or infrastructural challenges that hinder the large-scale adoption of second-generation biofuels in developing countries. **(Analyze)** 5. How do carbon credits or renewable energy subsidies influence investor interest in biofuel technologies? **(Apply)** **9-Mark Questions** 1. Critically analyze how national bioenergy policies and regulatory frameworks influence the innovation and commercialization of biofuel technologies in developing countries. **(Analyze)** 2. Evaluate the role of international climate agreements and sustainability standards in shaping the global adoption of advanced biofuel technologies. **(Analyze)** 3. Discuss how fluctuations in market dynamics such as oil prices, feedstock availability, and investment trends impact the development and deployment of biofuels. **(Apply/Analyze)** 4. Compare and contrast the impact of bioenergy policies in two countries of your choice and assess how these have affected the growth of their respective biofuel sectors. **(Analyze)**
Prepared by: Dr. Uma Krishnakumar, Asst. Professor, Department of Biotechnology Reviewed by: Dr. K Haribabu, Associate Professor, Dept. of Chemical Engg. , NIT Calicut	

24BTE414	BIOCHEMICAL THERMODYNAMICS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:
This course links the principles of classical thermodynamics to the complex chemical processes of living organisms. By understanding the laws of thermodynamics, free energy changes and equilibrium, students will gain insights into how biological systems harness, convert and regulate energy. It provides a conceptual and quantitative framework essential for careers in biotechnology, medicine, molecular biology and related fields.

Prerequisite: A solid foundation in basic physics, chemistry, and mathematics is essential.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Apply thermodynamic laws and concepts to biochemical systems.**[Apply]**
CO 2	Interpret and use thermodynamic diagrams to analyze systems.[**Analyze**]
CO 3	Calculate phase equilibria using activity coefficients and partial molar properties.[**Evaluate**]
CO 4	Apply the phase rule for reacting systems and to find the effect of various parameters equilibrium constants.[**Apply**]

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2									
CO2	2	3	2	2	2						
CO3	3	2									
CO4	2	3	2		2						

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]				
	Attendance	Assignment	Test-1	Test-2	Total Marks
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	40	60	2.5 hours
End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions, each question carries 3 marks Total Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Basic Concepts and Laws of Thermodynamics [9h]

System, Surrounding & Processes, Closed and Open systems, State Properties, Intensive and extensive Properties, State and Path functions, Equilibrium state, enthalpy, specific heat,
Reversible and Irreversible processes Zeroth law of thermodynamics, General statement of first law of thermodynamics, First law for cyclic Process, Non- Flow Process, Flow process, Heat capacity. Heat reservoir and Heat engines. General statements of the second law, Concept of entropy, Carnot principle, Calculation of entropy changes, Clausius inequality, Entropy and Irreversibility, Third law of Thermodynamics.
Equations of state for real gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, virial equation.

Self-Study (13h):

1. Read and strengthen the heat transfer mechanisms.
2. Learn about Thermodynamic cycles(Carnot, Rankine, Otto) and its applications.
3. Research the definition of equations of state such as Ideal gas law and real gas equations and
   solve problems based on it.
4. Study about refrigeration and heat pumps.

MODULE II: Properties of Pure Fluids and Thermodynamic Diagrams [9h]

Reference properties, energy properties, derived properties, work function, Helmholtz free energy, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations,
fundamental property relations, Maxwell's equations, Clapeyron equations, modified equations for

internal energy and enthalpy, effect of temperature on internal energy, enthalpy & Entropy. Gibbs-Helmholtz equation. Concept of Fugacity, Fugacity coefficient, effect of temperature and pressure on fugacity

Types of diagrams and construction of thermodynamic diagrams. Numericals on fugacity.

Self-Study (13h):

1. Read and understand the deviation of real gases from the ideal behavior.
2. Analyze phase equilibria and calculate vapor pressures.
3. Study the usage of thermodynamic tables to find properties like internal energy, enthalpy and entropy.
4. Understand phase behavior in binary systems.

MODULE III: Properties of solutions and Phase Equilibria [9h]

Partial molar properties of solution and its determination , chemical potential –effect of temperature and pressure , lewis randall rule, Raoults law for ideal solutions, fugacity in solutions, Henry's law and dilute solutions – ideal behavior of real solutions and Henry's law, Activity in solutions, Activity coefficients – effect of temperature and pressure, Gibbs -Duhem equation, calculation of activity coefficients using Gibbs-Duhem equation. Numericals on Gibbs free energy.

Criteria of phase Equilibria, criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, Consistency test for VLE data, Azeotropes.

Self-Study (14h):

1. Explore models like Wilson, NRTL, and UNIFAC for calculating activity coefficients.
2. Analyze causes and consequences of non-ideal behavior in solutions.
3. Understand the principles and calculations for vapor-liquid equilibrium.
4. Apply phase equilibria principles to design and optimize separation processes.

MODULE IV: Biochemical Energetics [9h]

Coupled reactions and energy rise compounds, Reaction Stoichiometry, criteria of biochemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature and pressure on equilibrium constants and other factors affecting equilibrium conversion, Le Chatelier's principle, liquid phase reactions, heterogeneous bioreaction equilibria, phase rule for reacting systems, Liquid-Liquid Equilibrium diagrams. Numericals on reaction stoichiometry and equilibrium constant.

Self-Study (14h):

1. Understand the role of ATP in energy transfer and coupling reactions.
2. Analyze oxidation-reduction reactions and their role in energy metabolism.
3. Apply biochemical energetics to understand energy metabolism during exercise.
4. Analyze the thermodynamics and kinetics of enzyme catalyzed reactions and understand the energetics of protein structure and stability.

Reference books

1. J. M. Smith, H. C. Van Ness, and M. M. Abbott, *Introduction to Chemical Engineering Thermodynamics*, 6th ed. New Delhi, India: Tata McGraw-Hill, 2003.
2. K. V. Narayanan, *A Textbook of Chemical Engineering Thermodynamics*, 1st ed. New Delhi, India: PHI Learning Pvt. Ltd., 2001.
3. S. I. Sandler, *Chemical and Engineering Thermodynamics*. Hoboken, NJ, USA: John Wiley & Sons, 1989.

NPTEL/SWAYAM Courses for reference:

1. NPTEL:: NOC:Chemical and biological thermodynamics: principles to applications
2. Swayam:: Chemical Engineering Thermodynamics

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	System, Surrounding & Processes, Closed and Open systems, State Properties, Intensive and extensive Properties, State and Path functions, Equilibrium state, enthalpy, specific heat.	1
1.2	Reversible and Irreversible processes Zeroth law of thermodynamics, General statement of first law of thermodynamics, First law for cyclic Process, Non- Flow Process, Flow process.	2
1.3	Heat capacity. Heat reservoir and Heat engines. General statements of the second law.	1
1.4	Concept of entropy, Carnot principle, Calculation of entropy changes, Clausius inequality, Entropy and Irreversibility, Third law of Thermodynamics.	2
1.5	Equations of state for real gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, virial equation.	3
	MODULE II [9 hours]	
2.1	Reference properties, energy properties, derived properties, work function, Helmholtz free energy, Gibbs free energy.	1
2.2	Relationships among thermodynamic Properties: Exact differential equations.	1
2.3	Maxwell's equations, Clapeyron equations, modified equations for internal energy and enthalpy, effect of temperature on internal energy, enthalpy & Entropy.	2
2.4	Gibbs-Helmholtz equation. Concept of Fugacity, Fugacity coefficient, effect of temperature and pressure on fugacity.	2
2.5	Types of diagrams and construction of thermodynamic diagrams.	1
2.6	Numericals on fugacity.	2
	MODULE III [9 hours]	

3.1	Partial molar properties of solution and its determination , chemical potential –effect of temperature and pressure.	1
3.2	Lewis –randall rule, Raoults law for ideal solutions, fugacity in solutions, Henry's law and dilute solutions – ideal behavior of real solutions and Henry's law.	2
3.3	Activity in solutions, Activity coefficients – effect of temperature and pressure, Gibbs -Duhem equation, calculation of activity coefficients using Gibbs-Duhem equation.	2
3.4	Numericals on Gibbs free energy.	2
3.5	Criteria of phase Equilibria, criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, Consistency test for VLE data, Azeotropes.	2
MODULE IV [9 hours]		
4.1	Coupled reactions and energy rise compounds, reaction stoichiometry.	1
4.2	Criteria of biochemical reaction equilibrium, equilibrium constant and standard free energy change, effect of temperature and pressure on equilibrium constants and other factors affecting equilibrium conversion.	2
4.3	Le Chatelier's principle, liquid phase reactions, heterogeneous bioreaction equilibria.	2
4.4	Phase rule for reacting systems, Liquid-Liquid Equilibrium diagrams.	2
4.5	Numericals on reaction stoichiometry and equilibrium constant.	2
CO Assessment Questions		
CO-1	**3 Mark Questions** 1. Distinguish between state function and path function with examples.**(Analyse)** 2. How Zeroth law of thermodynamics is helpful in measuring temperature? **(Apply)** 3. Compare Intensive and extensive properties with the help of an example.**(Understand)** 4. State the general statements of second law of thermodynamics **(Understand)** **9 Mark Questions** 1. Define the first law of thermodynamics. Derive mathematical relation for flow Process.**(Apply)** 2. Schematically represent the working of heat engine & heat pump. Explain how their efficiencies are evaluated.**(Analyse)** 3. Find the second & third virial coefficients of the van der waals equation when expressed in the form of $(P+a/V^2)(V-b) = RT$.**(Apply)**	

	4.Derive the relation between entropy and heat capacity **(Apply)**
CO-2	**3 Mark Questions** 1. Prove that C_p-C_v =R for ideal gas.**(Apply)** 2. Comment on concept of fugacity.**(Understand)** 3. Discuss effect of temperature on fugacity.**(Understand)** 4. Discuss effect of temperature on fugacity.**(Understand)** **9 Mark Questions** 1. Differentiate between reference properties, energy properties and derived properties.**(Understand)** 2. Using the relationship between C_p and C_v, show that $C_p - C_v = \beta^2 VT/K$. **(Apply)** 3. Derive the Maxwell's equation, from thermodynamics.**(Apply)** 4. Calculate the fugacity of liquid water at 303 K and 10 bar if the saturation pressure at 303 K is 4.241 KPa and the specific volume of liquid water at 303K is 1.004 X 10^{-3} m^3/Kg.**(Apply)**
CO-3	**3 Mark Questions** 1. State and explain Raoults law for ideal solutions.**(Understand)** 2. What is the effect of temperature and pressure on activity coefficients?**(Understand)** 3. A container is divided into two equal compartments. One contains 3.0 mole H_2(g) at 25°C; the other contains 1.0 mole N_2(g) at 25°C. Calculate the Gibbs energy of mixing when the partition is removed. Assume perfect behavior.**(Apply)** 4. Explain the applications of Gibbs Duhem equation**(Understand)** **9 Mark Questions** 1. Derive Gibbs Duhem equation.**(Apply)** 2. Define chemical potential. Explain the effect of temperature & pressure on chemical potential.**(Understand)** 3. Enunciate consistency test for VLE data.**(Understand)** 4. Explain Lewis Randall rule and Henry's law.**(Understand)**
CO-4	**3 Mark Questions** 1. What are the factors affecting equilibrium constant?**(Understand)** 2. Explain the feasibility of chemical reaction.**(Understand)** 3. Define the term Phase equilibria.**(Understand)** 4. Compare dew point and bubble point temperature **(Understand)** **9 Mark Questions** 1. Show that equilibrium constant & std. free energy change is given by $\Delta G^0 = -RT \ln K$ **(Apply)**

	2. The standard heat of formation and standard free energy of formation of ammonia at 298 K are 46,100 J/mol and 16,500 J/mol respectively. Calculate the equilibrium constant for the reaction, N_2 (g) + $3H_2$ (g) $\rightarrow 2NH_3$(g) at 500 K assuming that the standard heat of reaction is constant in the temp range 298 to 500 K.**(Evaluate)** 3. A gas mixture containing 3 mol CO_2, 5 mol H_2 & 1 mol water is understanding the following reaction: $CO_2+3H_2 \rightarrow CH_3OH + H_20$ $CO_2 + H_2 \rightarrow CO + H_2O$ Develop expressions for the mole fraction of the species in terms of the extent of reaction.**(Apply)** 4. State and explain Le-Chatliers principle with example.**(Understand)**
Prepared by: Mr. Francis John V, Asst. Professor, Department of Biotechnology	

24BTE415	BIOPHYSICS	L	T	P	R	C	Year of Introduction
		3	0	0	0	3	2024

Preamble:

Biophysics applies the principles of physics to understand biological systems, bridging the gap between engineering and life sciences. For engineering students, it offers a quantitative and analytical approach to study biomolecules, cells, and physiological processes. This course builds a foundation for innovations in biomedical devices, biotechnology, and healthcare technologies by integrating physics, biology, and engineering.

Prerequisite: Basic knowledge of Physics, Chemistry, and Cell Biology

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Understand the physical principles underlying biological macromolecules and cellular systems. **[Understand]**
CO 2	Apply thermodynamic and kinetic models to explain biomolecular behavior. **[Apply]**
CO 3	Analyze structural and functional data from biophysical techniques. **[Analyze]**
CO 4	Evaluate the role of biophysical tools in research and industrial biotechnology applications. **[Evaluate]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2	2							
CO2	3	3	3	3							
CO3	3	3	3	3	2						
CO4		3	3	3	3	3					

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember	√	√	√	√
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	
Create				

Mark Distribution of CIA

Course Structure [L-T-P-R]	Lecture [L]				
	Attendance	Assignment	Test-1	Test-2	Total Marks
3-0-0-0	5	10	12.5	12.5	40

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration

100	40	60	2.5 hours
End Semester Examination [ESE]: Pattern			
PATTERN	**PART A**	**PART B**	**ESE Marks**
PATTERN 1	8 Questions (2 Questions from each module), each question carries 3 marks Marks: (3x8 =24 marks)	2 questions will be given from each module, out of which 1 should be answered. Each question can have a maximum of two sub-divisions. Each question carries 9 marks. Marks: (9x4 = 36 marks)	60

SYLLABUS

MODULE I: Introduction to Biophysics & Biomolecular Structure [9h]

Scope and relevance of biophysics in biotechnology, Hierarchical structure of biological molecules: DNA, RNA, proteins, lipids; Molecular forces: hydrogen bonding, Van der Waals, hydrophobic and ionic interactions; Protein folding and stability; DNA melting and denaturation.

Self-Study (13h):

1. Primary, secondary, tertiary, and quaternary structure of proteins
2. Ramachandran plot and allowed conformations of amino acids
3. Base pairing rules and DNA supercoiling
4. Molecular dynamics of protein folding
5. Role of disulfide bonds in protein stability
6. Molecular recognition and specificity in biological interactions

MODULE II: Thermodynamics and Kinetics of Biological Systems [9h]

First and Second Laws of Thermodynamics in biological systems, Free energy, enthalpy, and entropy concepts, Chemical equilibrium and binding equilibria (e.g., enzyme-substrate, protein-ligand), Enzyme kinetics and Michaelis-Menten model, Allosteric interactions.

Self-Study (13h):

1. Gibbs free energy and its role in biological reactions
2. Entropy changes during protein folding
3. Cooperative binding: Hemoglobin and Hill equation
4. Steady-state vs. equilibrium in enzyme kinetics
5. Enzyme inhibition (competitive, non-competitive, uncompetitive)

MODULE III: Biophysical Techniques and Instrumentation [9h]

UV-Vis and Fluorescence Spectroscopy, Circular Dichroism (CD) Spectroscopy for protein structure analysis, X-ray Crystallography and Cryo-EM (introductory concepts), NMR Spectroscopy for biomolecular structure, Light scattering and analytical ultracentrifugation.

Self- Study (14h):

1. Fluorescence quenching and FRET in molecular interaction studies
2. Basics of cryo-electron microscopy and its significance in structural biology
3. X-ray diffraction pattern interpretation
4. Circular dichroism for alpha-helix and beta-sheet analysis
5. Basics of isothermal titration calorimetry (ITC) and differential scanning calorimetry (DSC)

MODULE IV: Biophysics of Cells and Membranes [9h]

Membrane structure and fluidity, Membrane transport: passive, active, ion channels; Electrophysiology: Nernst potential, membrane potential; Biomechanics: forces in cells, cytoskeletal dynamics; Optical tweezers and AFM in studying cells

Self-Study (14h):

1. Mechanisms of active and passive transport across membranes
2. Nernst equation and its application in cell potential estimation
3. Role of ion channels in nerve transmission
4. Mechanobiology and cellular force measurements
5. Use of atomic force microscopy (AFM) in membrane studies
6. Liposomes and exosomes as biomolecular delivery tools

Textbooks

1. R. Cotterill, *Biophysics: An Introduction*. Hoboken, NJ, USA: John Wiley & Sons, 2003.
2. C. R. Cantor and P. R. Schimmel, *Biophysical Chemistry: Part II — Techniques for the Study of Biological Structure and Function*. New York, NY, USA: Macmillan, 1980.
3. P. F. Dillon, *Biophysics: A Physiological Approach*. Cambridge, U.K.: Cambridge Univ. Press, 2012.

Reference books

1. M. Wikström, Ed., *Biophysical and Structural Aspects of Bioenergetics*, vol. 1. Cambridge, U.K.: Royal Society of Chemistry, 2005.
2. C. H. Kim and T. Ozawa, *Bioenergetics: Molecular Biology, Biochemistry, and Pathology*. Cham, Switzerland: Springer Science & Business Media, 2012.
3. V. P. Skulachev, A. V. Bogachev, and F. O. Kasparinsky, *Principles of Bioenergetics*. Cham, Switzerland: Springer Science & Business Media, 2012.

NPTEL/SWAYAM Courses for reference:

1. Cellular biophysics: a framework for quantitative biology
https://onlinecourses.nptel.ac.in/noc22_bt32/preview

2. Physics of Biological Systems
https://onlinecourses.nptel.ac.in/noc20_ph02/preview

3. Bio Physical Chemistry
https://nptel.ac.in/courses/104102009

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [36 hours]
	MODULE 1 [9 hours]	
1.1	Scope and relevance of biophysics in biotechnology	1
1.2	Hierarchical structure of biological molecules: DNA, RNA, proteins, lipids;	3
1.3	Molecular forces: hydrogen bonding, Van der Waals, hydrophobic and ionic interactions;	2
1.4	Protein folding and stability; DNA melting and denaturation.	3
	MODULE II [9 hours]	
2.1	First and Second Laws of Thermodynamics in biological systems	1
2.2	Free energy, enthalpy, and entropy concepts, Chemical equilibrium and binding equilibria (e.g., enzyme-substrate, protein-ligand),	3
2.3	Enzyme kinetics and Michaelis-Menten model	3
2.4	Allosteric interactions.	1
	MODULE III [9 hours]	
3.1	UV-Vis and Fluorescence Spectroscopy	2
3.2	Circular Dichroism (CD) Spectroscopy for protein structure analysis	2
3.3	X-ray Crystallography and Cryo-EM (introductory concepts)	2
3.4	NMR Spectroscopy for biomolecular structure	1
3.5	Light scattering and analytical ultracentrifugation	2
	MODULE IV [9 hours]	
4.1	Membrane structure and fluidity, Membrane transport: passive, active, ion channels	2

4.2	Electrophysiology: Nernst potential, membrane potential	2
4.3	Biomechanics: forces in cells, cytoskeletal dynamics	3
4.4	Optical tweezers and AFM in studying cells	2

CO Assessment Questions	
CO-1	1. Explain how non-covalent interactions stabilize protein and nucleic acid structures. **(Apply)** 2. Discuss the importance of the Ramachandran plot in understanding protein conformation. **(Apply)** 3. How does DNA denaturation occur, and what factors influence its melting temperature? **(Understand)** 4. Differentiate between hydrophobic and ionic interactions in biological molecules. **(Understand)**
CO-2	1. Define Gibbs free energy and explain how it governs spontaneous reactions in cells. **(Apply)** 2. What is the role of allosteric regulation in metabolic control? **(Analyze)** 3. Describe the differences between steady-state and equilibrium in enzyme kinetics. **(Apply)** 4. How can thermodynamic principles be applied to membrane transport mechanisms? **(Apply)**
CO-3	1. Compare UV-Vis spectroscopy and fluorescence spectroscopy in studying biomolecules. **(Apply)** 2. Explain the principle and application of circular dichroism in protein structure analysis. **(Apply)** 3. Describe how NMR is used to study the structure of biomolecules in solution. **(Analyze)** 4. Outline the working principle of a spectrophotometer and its application in biophysics. **(Apply)**
CO-4	1. Explain the structure and function of the lipid bilayer in cellular membranes. **(Understand)** 2. Describe how the membrane potential is generated and maintained. **(Apply)** 3. Discuss the significance of ion channels in cellular communication. **(Apply)** 4. How do optical tweezers help in the study of biomechanical properties of cells? **(Analyze)**
Prepared by: Dr. Dhanya Gangadharan, Associate Professor, Department of Biotechnology	

24BTE416	ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY	L	T	P	R	C	Year of Introduction
		3	1	0	1	5	2024

Preamble:
This course provides a comprehensive understanding of analytical techniques used in biotechnology, pharmaceuticals, food safety, and environmental sciences. Students will explore spectroscopy, chromatography, electrophoresis, and biosensors, gaining insights into their real-world applications in drug development, disease diagnostics, and industrial quality control.

Prerequisite: Basics of Chemistry, Physics & Mathematics.

Course Outcomes: After the completion of the course, the student will be able to

CO 1	Articulate the principles of spectroscopy, chromatography, and electrophoresis, demonstrating their relevance in biotechnology and industry applications.**[Understand and Apply]**
CO 2	Illustrate the principles and methodologies of chromatographic and analytical techniques. **[Apply]**
CO 3	Demonstrate an understanding of the principles and methodologies of electrophoretic and immunoanalytical techniques. **[Analyze]**
CO 4	Apply knowledge of centrifugation principles and analytical techniques for assessing contaminants in food and water, and critically evaluate bioprocess monitoring approaches and regulatory frameworks. **[Apply]**

CO-PO MAPPING

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1		3	3		3						2
CO2		3	3	2	3						2
CO3		3	3	2	3						2
CO4		3	3	2	3						2

Assessment Pattern

Bloom's Category	Continuous Assessment Tools			End Semester Examination
	Test1	Test 2	Other tools	
Remember				
Understand	√	√	√	√
Apply	√	√	√	√
Analyze	√	√	√	√
Evaluate			√	
Create				

Assessment Pattern for Project Component

Bloom's Category	Continuous Assessment Tools

	Evaluation 1	Evaluation 2	Report
Remember			
Understand			
Apply			
Analyze	√	√	√
Evaluate	√	√	√
Create	√	√	√

Mark Distribution of CIA

Course Structure [L-T-P-R]	Theory [L-T]							
	Attendance	Assignment	Test-1	Test-2	Evaluation 1	Evaluation 2	Report	Total Marks
3-1-0-1	5	5	7.5	7.5	10	10	5	50

Total Mark distribution

Total Marks	CIA (Marks)	ESE (Marks)	ESE Duration
100	50	50	2 hours

End Semester Examination [ESE]: Pattern

PATTERN	PART A	PART B	ESE Marks
PATTERN 2	2 Questions from each module. Any full 6 Questions, each carrying 3 marks (6x3=18 marks)	2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 3 sub-divisions. Each question carries 8 marks. Marks: (4x8 = 32 marks)	50

SYLLABUS

MODULE I: Spectroscopic Techniques and Biosensing Fundamentals 12h [9L + 3T]

Analytical techniques: Accuracy, precision, and sensitivity. UV-Visible spectroscopy: Beer-Lambert law, instrumentation, applications in nucleic acid and protein estimation. Fluorescence spectroscopy: Principles, fluorophores. Atomic absorption spectroscopy (AAS).

Infrared (IR) and FTIR spectroscopy: Functional group analysis. Basics of mass spectrometry, types of ionization (MALDI-TOF, ESI), applications in proteomics. Introduction to NMR spectroscopy and its applications.

Introduction to biosensors: types (electrochemical, optical, piezoelectric), Biosensor

components: bioreceptor, transducer, signal processor.

Tutorial:

Circular Dichroism (CD): Secondary structure determination of proteins, Applications of NMR spectroscopy in metabolite profiling and structural biology, Applications of biosensors in biochemistry and healthcare.

Self-Study (22h):

1. Compare single vs. double beam spectrophotometers, Identify key parts and their functions, Perform calibration steps conceptually.
2. Interpretation of UV-Vis absorption spectra for nucleic acids and proteins, Problem-solving: Calculate concentration using Beer-Lambert Law
3. **Case Study:** FRET-based Biosensors in Cancer Diagnostics – Self-research on fluorescence techniques in disease detection.
4. Research: Structure and function of a glucose biosensor
5. Diagram: Label key components of a typical biosensor

MODULE II: Chromatography 12h[9L + 3T]

Principles of chromatography, Paper and Thin-Layer Chromatography (TLC), Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Ion-exchange, Gel filtration, and Affinity chromatography, Combined techniques: LC-MS, GC-MS.

Tutorial:

Case-based problem: Choose the right chromatographic method for a protein mixture, Interpret chromatograms from HPLC and GC – retention times and peak areas, Group task: Match chromatography types to their principles and applications.

Self-Study (22h):

1. **NPTEL Course:** *Protein Separation Using Ion-Exchange & Gel Filtration* – IISc Bangalore (Biochemical purification methods.
2. Differentiate gel filtration and affinity methods. Case scenario: Choose the right column for a given protein mixture.
3. **Application-Based Study:** *Chromatographic Techniques in Biopharmaceutical Production* – research on monoclonal antibody purification strategies.
4. **Virtual Lab:** *Affinity Chromatography Interactive Simulator* – Protein-ligand binding visualization.

MODULE III:Electrophoresis, Immunotechniques, and Diagnostic Devices 12h[9L + 3T]

Principle and types of electrophoresis: Agarose gel, SDS-PAGE, Native vs. denaturing gels,
2D gel electrophoresis, Capillary electrophoresis; Blotting techniques: Southern, Northern, and Western blotting, ELISA principles and applications.
Point-of-care (POC) devices: types, microfluidic chips, lateral flow assays, POC examples: glucose meters, pregnancy tests, COVID-19 antigen kits; Design and validation of diagnostic kits

Tutorial:

Interpret SDS-PAGE or agarose gel electrophoresis results (molecular weight estimation),

Tutorial diagram: Label gel electrophoresis setup and explain buffer systems, Case scenario: Design a diagnostic workflow using ELISA for disease detection.

Self- Study (23h):

1. Draw a labeled diagram of a lateral flow device
2. Match: diagnostic scenario ↔ ELISA/POC device
3. Research: Working of a paper-based POC test strip
4. Create a table comparing lab-based vs. POC diagnostic platforms
5. Watch: video demo on microfluidic diagnostic devices and summarize

MODULE IV: Analytical Techniques and Applications in Industry 12h[9L + 3T]

Role of Analytical Techniques in Biotech Industries: Importance in quality control (QC) and quality assurance (QA), Regulatory requirements: GMP, GLP, FDA, ISO standards; Case examples from Pharma, Food tech, Diagnostics and Biofuels.

Tutorial:

Case analysis: Evaluate analytical test results from a pharmaceutical QC lab, Discussion: How biosensors are shaping the future of diagnostics in public health, Tutorial report: Role of point-of-care testing during the COVID-19 pandemic.

Self-Study (23h):

1. Industry Case Study: ELISA in COVID-19 Testing & Vaccine Development.
2. Select appropriate techniques for detecting each type of contaminant, Analyze sample lab report and identify if values are within regulatory limits.
3. Electrophoresis in Forensic Science – Analyzing DNA fingerprints from crime scenes.
4. Audit simulation: Spot 5 GLP/GMP non-compliances in a mock SOP, Create a mini checklist for sample handling in a regulated lab.

Reference books

1. D. A. Skoog, F. J. Holler, and S. R. Crouch, *Principles of Instrumental Analysis*, 7th ed. Boston, MA, USA: Cengage Learning, 2017.
2. K. W. Boehm, *Handbook of Bioanalytics: Analytical Techniques for Life Sciences*. Cham, Switzerland: Springer, 2022.
3. M. F. Vitha, *Chromatography: Principles and Instrumentation*. Weinheim, Germany: Wiley-VCH, 2016.
4. O. Wolfbeis, *Spectroscopic Methods in Bioanalytical Chemistry*. Weinheim, Germany: Wiley-VCH, 2015.

Additional Tools for Self-Learning (Recommended)

1. Braithwaite and F. J. Smith, *Chromatographic Methods*, 5th ed. Cham, Switzerland: Springer, 1999.
2. S. Weinberg, *Good Laboratory Practice Regulations*, 4th ed. Boca Raton, FL, USA: CRC Press, 2007.

NPTEL/SWAYAM Courses for reference:

1. NPTEL ::Analytical Technologies in Biotechnology, IIT Roorkee
   https://archive.nptel.ac.in/courses/102/107/102107028/

No.	COURSE CONTENTS AND LECTURE SCHEDULE	No. of Hours [48 hours]
	MODULE 1 [12 hours]	
1.1	Analytical Techniques: Accuracy, precision and sensitivity. UV-Visible spectroscopy: Beer-Lambert law, instrumentation, applications in nucleic acid and protein estimation.	1
1.2	Infrared (IR) and FTIR spectroscopy: Functional group analysis.	1
1.3	Fluorescence spectroscopy: Principles, fluorophores. Atomic absorption spectroscopy (AAS).	2
1.4	Basics of mass spectrometry, types of ionization (MALDI-TOF, ESI), applications in proteomics.	2
1.5	Introduction to NMR spectroscopy and its applications.	1
1.6	Introduction to biosensors: types (electrochemical, optical, piezoelectric), Biosensor components: bioreceptor, transducer, signal processor.	2
1.7	**Tutorial:**Circular Dichroism (CD): Secondary structure determination of proteins, Applications of NMR spectroscopy in in metabolite profiling and structural biology, Applications of biosensors in biochemistry and healthcare.	3
	MODULE II [12 hours]	
2.1	Principles of Chromatography, Paper and Thin Layer Chromatography (TLC)	1
2.2	Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC).	2
2.3	Column Chromatography - Gel Filtration & Affinity Chromatography	3
2.4	Ion-exchange, Combined techniques: LC-MS, GC-MS.	3
2.5	Case-based problem: Choose the right chromatographic method for a protein mixture, Interpret chromatograms from HPLC and GC – retention times and peak areas, Group task: Match chromatography types to their principles and applications.	3
	MODULE III [12 hours]	
3.1	Principle and types of electrophoresis: Agarose gel, 2D gel electrophoresis.	1
3.2	SDS-PAGE, Native vs. denaturing gels.	1
3.3	2D Gel Electrophoresis, Capillary	1
3.4	Blotting techniques: Southern and Northern blotting.	2
3.5	Western blotting.	1

3.6	ELISA principles and applications.	1
3.7	Point-of-care (POC) devices: types, microfluidic chips, lateral flow assays, POC examples: glucose meters, pregnancy tests, COVID-19 antigen kits; Design and validation of diagnostic kits	2
3.8	**Tutorial:**Interpret SDS-PAGE or agarose gel electrophoresis results (molecular weight estimation), Tutorial diagram: Label gel electrophoresis setup and explain buffer systems, Case scenario: Design a diagnostic workflow using ELISA for disease detection	3
MODULE IV [12 hours]		
4.1	Role of Analytical Techniques in Biotech Industries: Importance in quality control (QC) and quality assurance (QA)	1
4.2	Regulatory requirements: GMP, GLP standards.	2
4.3	Regulatory requirements: FDA, ISO standards.	2
4.4	Case examples from pharma and food industry.	2
4.5	Case examples from diagnostic and biofuels.	2
4.6	**Tutorial:**Case analysis: Evaluate analytical test results from a pharmaceutical QC lab, Discussion: How biosensors are shaping the future of diagnostics in public health, Tutorial report: Role of point-of-care testing during the COVID-19 pandemic	3
PROJECT		
The project component of Analytical Techniques in Biotechnology offers students practical experience in applying key analytical tools such as spectroscopy, chromatography, and electrophoresis. It aims to build technical skills, analytical thinking, and scientific reporting abilities, preparing students for research and industry roles in biotechnology.		
LESSON PLAN FOR PROJECT COMPONENT		
No.	**TOPIC**	**No. of Hours [12]**
1	Preliminary Design of the Project	2
2	Zeroth presentation (4th week)	2
3	Project Work - First Phase	2
4	Interim Presentation	2
5	Project work - Final Phase & Report writing (discussions in class during project hours)	2
6	Final Evaluation, Presentation and Exhibition(11th and12th weeks)	2
CO Assessment Questions		
	3-Mark Questions 1. Define accuracy, precision, and sensitivity in the context of analytical techniques. **(Understand)** 2. State Beer-Lambert's Law and explain the relationship between absorbance and concentration. **(Understand)**	

CO-1	3. Differentiate between single-beam and double-beam UV-visible spectrophotometers. **(Apply)** 4. Explain how infrared (IR) spectroscopy is used to analyze functional groups in organic molecules. **(Analyze)** **9-Mark Questions** 1. Explain the principles and instrumentation of UV-Visible spectroscopy. Discuss the calibration and standardization process in detail. **(Understand)** 2. Compare and contrast fluorescence and phosphorescence spectrometry. Describe their underlying principles and key instrumentation components. **(Apply)** 3. Explain the different types of mass spectrometry ionization techniques (MALDI-TOF, ESI) and evaluate their impact on proteomics research. **(Analyze)** 4. Describe NMR spectroscopy and its applications in metabolite profiling and structural biology. **(Apply)**
CO-2	**3-Mark Questions** 1. Define the principle of separation in chromatographic techniques and identify two key factors that influence separation. **(Understand)** 2. Compare Thin Layer Chromatography (TLC) and Paper Chromatography in terms of principle and application. **(Apply)** 3. Enumerate the basic steps involved in gel filtration chromatography. **(Understand)** 4. Differentiate between GC -MS and LC-MS. **(Apply)** **9-Mark Questions** 1. Describe and compare the principles and methodologies of High-Performance Liquid Chromatography (HPLC) and Gas Chromatography (GC). **(Apply)** 2. Explain the methodology of affinity chromatography and discuss its application in protein purification. **(Apply)** 3. A regulatory body has flagged the presence of pesticide residues in a batch of imported fruits. Describe how GC-MS can be used to quantify and identify these residues. Outline the sample preparation, chromatographic separation, and mass spectrometric detection steps. **(Analyze)** 4. Explain the methodologies of various chromatographic techniques, including HPLC, GC, and ion-exchange chromatography. Compare their advantages and limitations in analytical applications. **(Apply)**

CO-3	**3-Mark Questions** 1. Differentiate between SDS-PAGE and Native PAGE in terms of principle and protein separation. **(Understand)** 2. State the purpose of using agarose gel in nucleic acid electrophoresis. **(Apply)** 3. List any three applications of ELISA in clinical or research settings. **(Understand)** **9-Mark Questions** 1. Explain the principles and procedural steps of 2D Gel Electrophoresis. Discuss how it enhances protein resolution compared to 1D methods. **(Apply)** 2. Describe the Western blotting technique. Illustrate the transfer, blocking, and detection steps involved in protein identification. **(Apply)** 3. Discuss the fundamental principles of ELISA. Explain its components and analyze how it is used to characterize cell populations. **(Apply)** 4. Given an SDS-PAGE gel with multiple bands of varying intensities, how would you interpret the protein expression levels? How does antibody specificity influence the accuracy of Western blot results. **(Analyze)**
CO-4	**3-Mark Questions** 1. Discuss how UV-Visible spectroscopy helps in monitoring contaminants in food and water samples. **(Apply)** 2. List any three commonly used analytical methods for detecting heavy metal contamination in water. **(Apply)** 3. State the role of Process Analytical Technology (PAT) in bioprocess monitoring. **(Apply)** 4. List the major regulatory agencies governing analytical techniques in food and water testing and briefly describe their role. **(Understand)** **9-Mark Questions** 1. Describe the analytical techniques used for detecting microbial contamination in food and pesticide residues. Discuss their sensitivity and reliability. **(Apply)** 2. Discuss the importance of GLP, GMP, and ISO standards in analytical laboratories. Analyze how regulatory compliance impacts data quality and product safety. **(Analyze)** 3. Critically assess the bioprocess monitoring approaches required for regulatory compliance in biotechnology industries. **(Analyze)**
Prepared by: Ms.Steny Mary Anto, Asst. Professor and Dr. Dhanya Gangadharan, Associate Professor, Department of Biotechnology	