SEMESTER 3

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

SEMESTER S3

MATHEMATICS FOR LIFE SCIENCE – 3

(Group D)

Course Code	**GDMAT301**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic calculus	**Course Type**	Theory

Course Objectives:

1. To provide a solid understanding of probability theory and its practical applications to address uncertainty and variability in engineering systems effectively.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Summarizing data sets, Sample mean, Median and mode, Sample variance and standard deviation, Normal data sets, Paired data sets and sample correlation coefficient. **(Text1: Relevant topics from sections 2.3.1, 2.3.2, 2.5, 2.6)**	**9**
2	Introduction to probability, Sample space and events, Venn diagrams, Axioms of probability, Sample spaces having equally likely outcomes, Conditional probability, Baye's formula, Independent events. **(Text1: Relevant topics from sections 3.1, 3.2, 3.3,3.4, 3.5, 3.6, 3.7, 3.8)**	**9**
3	Random variables, Discrete and continuous random variables, Probability mass function and Probability density function, Cumulative distribution function, Expectation, Expectation of a function of a random variable and its properties, Variance and standard deviation. **(Text1: Relevant topics from sections 4.1, 4.2, 4.4, 4.5, 4.6)**	**9**

4	The Bernoulli and binomial random variables and its distribution, The Poisson random variable and its distribution, Uniform distribution, Normal and standard normal distribution. **(Text1: Relevant topics from sections 5.1, 5.2, 5.4, 5.5)**	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the methods of descriptive statistics to summarize and analyze data systematically.	**K2**
CO2	Understand the basics of probability theory and to apply the fundamental concepts and methods to analyze uncertainty and make predictions.	**K3**
CO3	Apply the concept of random variables and their associated probability distributions to study random phenomena.	**K3**
CO4	Understand the fundamental probability distributions and to apply statistical techniques effectively to make informed decisions based on probabilistic analysis.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	2	-	-	-	-	-	-	-	2
CO2	3	3	-	2	-	-	-	-	-	-	-	2
CO3	3	3	-	2	-	-	-	-	-	-	-	2
CO4	3	3	-	2	-	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Probability and Statistics for Engineers and Scientists	Sheldon M Ross	Academic Press	6^{th} edition, 2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Probability, Statistics and Random processes	T Veerarajan	Mc Graw Hill	3rd edition, 2008.
2	Probability and Statistics for Engineering and the Sciences	Devore Jay L	Cengage	9th edition, 2016.
3	Statistical Methods	S.P. Gupta	Sultan Chand & Sons	46th edition, 2021.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_mg31/preview
2	https://onlinecourses.nptel.ac.in/noc22_mg31/preview
3	https://onlinecourses.nptel.ac.in/noc22_mg31/preview
4	https://onlinecourses.nptel.ac.in/noc22_mg31/preview

SEMESTER S3

BIOCHEMISTRY

Course Code	**PCBBT302**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-1-0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge in biology and chemistry	**Course Type**	Theory

Course Objectives:

1. To understand the structure of the various biomolecules and their metabolism
2. To understand the role of energy in the biochemical process in living organism.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Biomolecules-Structure, chemistry and reactions Carbohydrate: simple sugars and polysaccharides, complex carbohydrates Lipids-: fatty acids, phospholipids and sphingolipid, cholesterol, steroids, prostaglandins Proteins: primary, secondary, tertiary and quaternary structure of proteins, membrane proteins Nucleic acids: primary structure, secondary, tertiary structure of DNA & RNA	**11**
2	Metabolism of Biomolecules Overview of metabolism (aerobic, anaerobic, anabolic, catabolic). Techniques used in the study of metabolism (principle only -tracer,chromatography). Major metabolic Pathways:(Pathway and regulation) Glycolysis,TCA cycle, Gluconeogenesis, HMP pathway, Glycogen Metabolism: Glycogenesis, glycogenolysis.	**11**
3	Metabolism of Biomolecules Biosynthesis of saturated fatty acids, β-oxidation pathway (only saturated fatty acids), ketone bodies, biosynthesis and degradation of aromatic amino acids,Transport of fatty acid into mitochondria,Carnitine shuttle:	**11**

	General reactions of amino acid metabolism: transamination, transdeamination, oxidative deamination and decarboxylation, Urea cycle and regulation.	
4	Bioenergetics: Electron Transport Chain & Oxidative phosphorylation: sequence of electron carriers: sites of ATP synthesis, inhibitors of electron transport chain. Chemiosmotic theory, inhibitors and uncouplers, Malate aspartate and glycerol-3-phosphate shuttle. Photosynthesis: light reaction, cyclic and noncyclic photophoshorylation, dark reaction, fixation of CO_2 and formation of carbohydrate, C3 and C4 plants, photorespiration, CAM pathway	**11**

Course Assessment Method
(CIE: 40 marks,ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the structure and reactions of the cellular biomolecules.	**K2**
CO2	Describe biosynthetic pathways and understand the key aspects of metabolism.	**K3**
CO3	Explain cellular energy requirements and their production	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2	2		3	2					2
CO2	3		2	2		3	2					2
CO3	3		2	2		3	2					2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Biochemistry	Albert Lehninger, David L Nelson, Michael M Cox,	CBS Publishers & Distributors, Delhi	Principles of Biochemistry
2	Biochemistry	Donald Voet, Judith G. Voet	Publisher: John Wiley & Sons	Biochemistry
3	Fundamentals of Biochemistry	J.L.Jain, Sanju Jain & Nitin Jain	Chand and Co Ltd	Fundamentals of Biochemistry

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biochemistry	LubertStryer	W.H Freeman and Company, New York	Biochemistry

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/102/106/102106087/ https://archive.nptel.ac.in/courses/102/106/102106087/
2	https://archive.nptel.ac.in/courses/102/106/102106087/
3	https://youtu.be/DOy1fSRV5mU
4	https://archive.nptel.ac.in/courses/102/106/102106087/ https://archive.nptel.ac.in/courses/102/106/102106087/

SEMESTER S3

MICROBIOLOGY

(COMMON FOR BIOTECHNOLOGY/BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING)

Course Code	**PCBBT303**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-1-0-0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. This course aims to prepare the students to understand the role of various groups of microorganisms in different fields of human endevour.
2. Course also aims to figure out various techniques in visualization of microrganisms and develop methods to culture them.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Refutation of abiogenesis-** Major contribution of scientists. **Classification and Identification of microorganisms-** Bacteria & Fungus. **Microscopic examination of Microorganisms-** morphology and fine structure of bacteria& Fungus. Bacterial reproduction **Virology-** General classification of virus, (structure, nucleic acid) Bacteriophage, TMV, life cycle of viruses, lytic cycle (T4) and lysogenic (lambda).	**10**
2	**Microscopy-** Principles and applications of dark field, bright field, fluorescent,TEM and SEM, Confocal, Phase contrast Microscopy. **Major staining techniques-** Simple, Gram, Acid fast, Spore staining, Staining of flagella & capsule **Cultivation of bacteria–**Types of growth media natural, synthetic, complex, enriched, selective- definition with example,	**11**

	Pure culture methods- streak plate, spread plate, pour plate, stab culture, slant culture. **Anaerobic Culture of microbes-** Thioglycolate, anaerobic chamber, Robertson's media, microaerophilic	
3	**Bacterial Growth**- Growth curve, Mathematical derivation of growth curve. Direct and indirect measurement of growth **Influence of environmental factors**-pH, temperature, oxygen, Heavy metals and Other compounds. Nutritional classes of microorganisms **Control of microbes**- Sterilisation, disinfection, antiseptic, tyndallization, pasteurization: **Physical**- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical compounds, anionic and cationic detergents.	**10**
4	**Soil microbiology**: interactions existing between microorganisms- positive and negative interactions. **Biogeochemical cycles**- Cycles of carbon, nitrogen and sulphur. **Microbiological analysis of water:** Sanitary tests for coliforms: presumptive, confirmed, completed tests, IMViC tests. **Pathogenesis of water borne diseases–** cholera, typhoid**Foodmicrobiology :**Bacteria and fungi causing food spoilage.**Food preservation techniques**: physical and chemical methods**. Foodborne diseases**: food infections and intoxications.**Industrial Microbiology**-Microorganisms as biofertilizers and biopesticides.	**11**

Course Assessment Method
(CIE: 40 marks,ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the basic concepts of visualization and classification of microorganisms	**K2**
CO2	Illustrate the different techniques for growth and control of microorganisms	**K2**
CO3	Understand the role of microorganisms in environment.	**K2**
CO4	Summarize the importance of microorganisms in different industries.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		2	2							
CO2	3	2										2
CO3	3	2					2					2
CO4	3	2										2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Microbiology.	Prescott, Harley and Klein	McGraw Hill International Edition	2nd Edition, 2008
2	Microbiology	Pelczar M. J., E. C. E. Chan and N. R. Krieg	Tata McGraw Hill	5th Edition, 1993
3	Brock Biology of Microorganism	Michael T Madigan, Buckley and Stahl	Pearson	14th edition 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An introduction to Microbiology	Kapoor,Yadav and Tauro	New Age International Publications	4th edition, 2023
2	Microbiology An Introduction	Tortora, Funk and Case	Pearson	13th edition, 2021

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL :: https://archive.nptel.ac.in/courses/102/103/102103015/
2	NPTEL :: https://archive.nptel.ac.in/courses/102/103/102103015/
3	https://archive.nptel.ac.in/courses/102/103/102103015/
4	NPTEL ::MICROBIOLOGY - https://nptel.ac.in/courses/105107173

SEMESTER S3

INDUSTRIAL BIOPROCESS TECHNOLOGY

Course Code	**PBBTT304**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. The course shall cover all applied aspects of enzymes and microbes for the manufacturing of products in diverse fields of an integrated bioprocess system
2. The course majorly focuses on the applications and allows students to gain practical knowledge rather than mere theory

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	A brief account of the development of fermentation technology. Role of bioprocess Engineer in Bioprocess Industry. Process flow sheeting. Outline of the various unit operations used in upstream and downstream operations in a bioprocess industry. Isolation, and preservation of industrially important microorganisms, improvement of industrially important micro-organisms using protoplastfusion and DNA technology. Criteria for the transfer of inoculums, development of inoculum for yeast and bacterial cultures.	**11**
2	Market economics of a Bioprocess Industry: Capital cost estimation - operating cost estimation - profitability analysis - GMP and cGMP, Utilities in a bioprocess plant. Industrial processes for the manufacture with the important engineering problems involved in the manufacture of the following products with a flow	**11**

	diagram, reactions and condition: Primary metabolites- Organic acids (Citric and lactic acid), Amino acids (Glutamic acid, lysine), Alcohols (Ethanol, acetone-butanol) Industrial Applications of primary metabolites	
3	Industrial processes for the manufacture with the important engineering problems involved in the manufacture of the following products with flow diagram, reactions and condition: Secondary metabolites- Antibiotics (Penicillin, Streptomycin), Vitamins (Vitamin B2, Vitamin B12), Steroid transformation process. Industrial Applications of secondary metabolites. Microbial production of industrial enzymes: (Proteases, amylases) Industrial Applications of enzymes. Production of recombinant proteins: Manufacture of human insulin, Hepatitis B vaccine, Monoclonal antibody production. Industrial Applications of recombinant proteins.	**11**
4	Products of eco-friendly technology: Production of xanthan gum, PHB, Nisin, SCP, Biofertilizer (Rhizobium, Azotobacter) andBiopesticide(*Bacillus thuriengiensis*), Biohydrogen and biomethane production. General treatment(Primary secondary and tertiary treatments)and disposal methods of effluents generated from the fermentation industry.	**11**

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 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 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Interpret the use of microorganisms for the production of value-added commercial products.	**K3**
CO2	Apply the biological and engineering principles in the production of bio products and enzymes	**K3**
CO3	Summarize the Market economics in the production of a bio product	**K2**
CO4	Understand the concepts involved in the treatment and disposal of effluents from fermentation industry.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2	2		2	2	2	2		2
CO2	3	2		2	2				2	2		2
CO3	3	2				2			2	2	2	2
CO4	3	2				2		2	2	2		2
CO5	3	2	2	2	2			2	2	2	2	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Industrial Microbiology	Casida Jr, L. E	New Age International (P) Ltd	1996
2	Principles of fermentation Technology	P F Stanbury, A Whitaker and S J Hall	Elsevier	1995
3	Biotechnology: A Textbook of Industrial Microbiology	Cruger W. and A. Crueger	Madison, Wi Science technology	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biocatalysts and Enzyme Technology,	K. Buchholz, V. Kasche, U.T. Bornscheuer	WILEYVCH	2005
2	Fermentation microbiology and biotechnology	E M T El Mansi, C F A Bryce, B Dahhou S Sanchez, A L Demain, A R Allmen	CRC Press	2012
3	Fundamentals of recombinant protein production, purification and characterization	Deepti Yadav, Guldhe and Kudanga	Elsevier, Science	2024

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/102/105/102105058/
2	
3	
4	
5	

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	Practical	Presentation
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		30

1. **Project Planning and Proposal (5 Marks)**

   - Clarity and feasibility of the project plan
   - Research and background understanding
   - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

   - Individual contribution to the presentation
   - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

   - Active participation and individual contribution
   - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**

   - Quality and clarity of the overall presentation
   - Individual contribution to the presentation
   - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

   - Overall quality and technical excellence of the project
   - Innovation and originality in the project
   - Creativity in solutions and approaches

SEMESTER S3

INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Course Code	**GNEST305**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Demonstrate a solid understanding of advanced linear algebra concepts, machine learning algorithms and statistical analysis techniques relevant to engineering applications, principles and algorithms.
2. Apply theoretical concepts to solve practical engineering problems, analyze data to extract meaningful insights, and implement appropriate mathematical and computational techniques for AI and data science applications.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to AI and Machine Learning**: Basics of Machine Learning - types of Machine Learning systems-challenges in ML- Supervised learning model example- regression models- Classification model example- Logistic regression-unsupervised model example- K-means clustering. Artificial Neural Network- Perceptron- Universal Approximation Theorem (statement only)- Multi-Layer Perceptron- Deep Neural Network- demonstration of regression and classification problems using MLP.(Text-2)	11
2	**Mathematical Foundations of AI and Data science**: Role of linear algebra in Data representation and analysis – Matrix decomposition- Singular Value Decomposition (SVD)- Spectral decomposition- Dimensionality reduction technique-Principal Component Analysis (PCA). (Text-1)	11
3	**Applied Probability and Statistics for AI and Data Science**: Basics of probability-random variables and statistical measures - rules in probability-	11

	Bayes theorem and its applications- statistical estimation-Maximum Likelihood Estimator (MLE) - statistical summaries- Correlation analysis- linear correlation (direct problems only)- regression analysis- linear regression (using least square method) (Text book 4)	
4	**Basics of Data Science**: Benefits of data science-use of statistics and Machine Learning in Data Science- data science process - applications of Machine Learning in Data Science- modelling process- demonstration of ML applications in data science- Big Data and Data Science. (For visualization the software tools like Tableau, PowerBI, R or Python can be used. For Machine Learning implementation, Python, MATLAB or R can be used.)(Text book-5)	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply the concept of machine learning algorithms including neural networks and supervised/unsupervised learning techniques for engineering applications.	**K3**
CO2	Apply advanced mathematical concepts such as matrix operations, singular values, and principal component analysis to analyze and solve engineering problems**.**	**K3**
CO3	Analyze and interpret data using statistical methods including descriptive statistics, correlation, and regression analysis to derive meaningful insights and make informed decisions.	**K3**
CO4	Integrate statistical approaches and machine learning techniques to ensure practically feasible solutions in engineering contexts.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3	3								
CO2	3	3	3	3								
CO3	3	3	3	3								
CO4	3	3	3	3								

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Linear Algebra	Gilbert Strang	Wellesley-Cambridge Press	6th edition, 2023
2	Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow	AurélienGéron	O'Reilly Media, Inc.	2nd edition,2022
3	Mathematics for machine learning	Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong	Cambridge University Press	1st edition. 2020
4	Fundamentals of mathematical statistics	Gupta, S. C., and V. K. Kapoor	Sultan Chand & Sons	9th edition, 2020
5	Introducing data science: big data, machine learning, and more, using Python tools	Cielen, Davy, and Arno Meysman	Simon and Schuster	1st edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Data science: concepts and practice	Kotu, Vijay, and Bala Deshpande	Morgan Kaufmann	2nd edition, 2018
2	Probability and Statistics for Data Science	Carlos Fernandez-Granda	Center for Data Science in NYU	1st edition, 2017
3	Foundations of Data Science	Avrim Blum, John Hopcroft, and Ravi Kannan	Cambridge University Press	1st edition, 2020
4	Statistics For Data Science	James D. Miller	Packt Publishing	1st edition, 2019
5	Probability and Statistics -The Science of Uncertainty	Michael J. Evans and Jeffrey S. Rosenthal	University of Toronto	1st edition, 2009
6	An Introduction to the Science of Statistics: From Theory to Implementation	Joseph C. Watkins	chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.math.arizo	Preliminary Edition.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/106/106/106106198/
2	https://archive.nptel.ac.in/courses/106/106/106106198/ https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/resources/lecture-29-singular-value-decomposition/
3	https://ocw.mit.edu/courses/18-650-statistics-for-applications-fall-2016/resources/lecture-19-video/
4	https://archive.nptel.ac.in/courses/106/106/106106198/

SEMESTER S3/S4

ECONOMICS FOR ENGINEERS

(Common to All Branches)

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	6
2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	6
3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation	6

	Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators- SENSEX and NIFTY	
4	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 - Cost-Benefit Analysis - Capital Budgeting - Process planning	**6**

Course Assessment Method
(CIE: 50 marks , ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Case study/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
10	15	12.5	12.5	50

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks **(6x3 =18marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. **(4x8 = 32 marks)**	**50**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting techniques.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7^{TH} Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S3/S4

ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics** - Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places**-accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies -** sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in connection with**	6

	gender - equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world	**6**

	case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

Course Assessment Method
(CIE: 50 marks , ESE: 50)

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12
3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1						3	2	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:

Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business

plan.

- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S3

BIOCHEMISTRY LAB

Course Code	**PCBBL307**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0-0-3-0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCBBT302 Basic knowledge of Biochemistry	**Course Type**	Lab

Course Objectives:

1. To familiarize students with the basic instrumental techniques necessary for analysis of bioprocess systems
2. To provide practical skills in handling and characterizing biomolecules

Expt. No.	Experiments
1	Qualitative tests for Carbohydrates
2	Qualitative tests for Amino Acids
3	Quantitative estimation of sugars (anyone) 1. Estimation of reducing sugars by the Nelson Somogyi method. 2. Estimation of reducing sugars by Benedict's method. 3. Estimation of reducing sugars by the DNS method. 4. Estimation of fructose by the Resorcinol method
4	Quantitative estimation of amino acids and proteins (any two) 1. Estimation of protein Biuret method. 2. Estimation of protein by Folin's method. 3. Estimation of amino acid by sugars by the Ninhydrin method 4. Estimation of Tyrosine by sugars by the Folin's method
5	Quantitative estimation of nucleic acids 1. Estimation of DNA by Diphenylamine reagent method. 2. Estimation of RNA by Orcinol reagent method.
6	Quantitative estimation of cholesterol by Zak's method
7	Estimation of Thiamine and Riboflavin by Fluorimetry
8	Saponification of fats

9	Precipitation of proteins by ammonium sulphate
10	Paper chromatography - Separation of amino acids by paper chromatography & determination of Rf value.
11	Thin Layer chromatography - Extraction of lipids and separation using thin layer Chromatography
12	Column chromatography -Determination of molecular weight of macromolecules

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the preparation of reagents for various biochemistry experiments.	**K2**
CO2	Apply knowledge in Qualitative analysis and estimation of different biomolecules	**K3**
CO3	Understand the basic bioseparation process.	**K2**
CO4	Apply the knowledge and skills acquired to analyze and interpret experimental data obtained from different analytical instruments and communicate results effectively.	**K3**

Note: *K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2		2			2	2	3	2		2
CO2	2	2		2			2	2	3	2		2
CO3	2	2		2			2	2	3	2		2
CO4	2	2		2			2	2	3	2		2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	BiochemicalMethods,	S. Sadasivam,	New Age International	
2	Introductory Practical Biochemistry	S. K. Sawhney &Randhir Singh (eds)	Narosa Publishing House, New Delhi,	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Practical Biochemistry,	David T. Plummer	McGraw-Hill	
2	Modern Experimental Biochemistry	Rodney and Boyer	Pearson Education, India.	
3	Hawks Physiological Chemistry	Hawk, Bernard L.Oser (ed).TATA	McGraw Hill Publishing Company LTD, New Delhi	

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S3

MICROBIOLOGY LAB

(COMMON TO BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING (BB) AND BIOTECHNOLOGY ENGINEERING (BT) BRANCHES/D GROUP/GROUPS)

Course Code	**PCBBL308**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0-0-3-0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Lab

Course Objectives:

1. Isolate, identify and characterize microorganisms from various sources
2. Understand the role of microorganisms in various fields of human endeavor.

Expt. No.	Experiments
1	Introduction to principles of sterilization techniques.
2	Preparation of media and media components
3	Isolation and cultural characterization of bacteria from different sources.
4	Isolation of pure culture of microorganisms by using different plating techniques.
5	Short-term and long-term preservation techniques of microorganisms
6	Identification of Bacteria using simple staining and gram staining techniques.
7	Identification of Bacteria using endospore staining and nuclear staining technique
8	Enumeration of microorganisms using a hemocytometer
9	Measurement of growth - Wet weight and dry weight measurements
10	Microbiological examination of water.
11	Biochemical tests: IMVIC test, Catalase test, Gelatinase test, Oxidase test, and other related tests.
12	Microbiological testing of milk: MBRT test
13	Antibiotics sensitivity test; Kirby Bauer method or Disc diffusion method
14	Testing of microbial capacity to produce biologically active substance

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply appropriate laboratory techniques and methodology for the isolation, characterization, propagation, and enumeration of microorganisms in a given sample	**K3**
CO2	Illustrate the proper usage of various microscopes and visually recognize the microscopic characteristics of bacteria and other microbes	**K2**
CO3	Understand the impact of microorganisms on agriculture, the environment, and human health	**K2**
CO4	Apply appropriate microbiological laboratory techniques, methodologies, instruments, and equipment following current laboratory safety protocol.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1				2						
CO2	2	1				2						
CO3	2	1										2
CO4	2	1				2						2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Laboratory Manual in General Microbiology,	.Alfred Brown,	McGraw Hill Publications,	2004
2	Laboratory manual in Microbiology,	Gunasekharan P,	New Age International Publishers,	2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	A Laboratory Manual in Microbiology	Cappuccino J. G. and N. Sherman,	New Age International Publishers,	2007
2	Molecular Microbiology: Diagnostic Principles and Practice	Tang Y, Unger ER, Relman DA, White TJ eds.	American Society for MicrobiologyPress	2004

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	nptel.ac.in/courses/102/103/102103015/
2	https://onlinecourses.swayam2.ac.in/cec22_bt20/preview

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

   - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
   - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

   - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
   - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
   - Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

   - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
   - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

   - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

   - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
   - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.

- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 4

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

Common for
BIOTECHNOLOGY ENGINEERING

SEMESTER S4

MATHEMATICS FOR LIFE SCIENCE – 4

(Group D)

Course Code	GDMAT401	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	GDMAT301	Course Type	Theory

Course Objectives:

1. To provide a comprehensive understanding of the concepts of population and sample distinctions, interval estimation, hypothesis testing, the method of least squares for regression, and ANOVA for variance analysis and to apply them in practical applications across various fields.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Population and sample, The sample mean, Population mean and variance, The central limit theorem – Distribution of sum of random variables, Approximate distribution of the sample mean, Sample variance and sample standard deviation. **[Text 1: Relevant topics from sections 6.1,6.2,6.3, 6.3.1,6.3.2, 6.4]**	9
2	Interval estimation of population mean - Two sided confidence interval, One-sided lower and upper confidence intervals, Confidence interval for the mean when the variance is unknown, Confidence intervals for the variance of a normal distribution. **[Text 1: Relevant topics from sections 7.3, 7.3.1, 7.3.3]**	9
3	Hypothesis testing, Significance levels, Null hypothesis, Critical region, Type I and Type II error, Testing of mean of a normal population – Case of known variance, One sided tests; Testing of mean of a normal population- Case of unknown variance, One sided *t*- test. **[Text 1: Relevant topics from sections 8.1, 8.2, 8.3.1, 8.3.1.1, 8.3.2]**	9

4	The method of least squares-regression line, Multiple regression (for two independent variables only), Analysis of variance, Completely randomized design (One-way ANOVA), Randomized-block design (Two-way ANOVA). **[Text 2: Relevant topics from sections 11.1, 11.4, 12.1, 12.2, 12.3]**	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand population and sample distinctions, calculate means and variances and to apply the central limit theorem to distributions of sums of random variables.	**K3**
CO2	Construct interval estimates for population means using two-sided and one-sided confidence intervals, to determine confidence intervals for the mean with unknown variance, and to calculate confidence intervals for the variance of a normal distribution.	**K3**
CO3	Understand the basic concepts of hypothesis tests and to apply them in testing means of normal populations with known and unknown variances.	**K3**
CO4	Apply the method of least squares to determine regression lines to conduct multiple regression analysis for two independent variables and to perform analysis of variance (ANOVA) including completely randomized and randomized-block designs.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	-	-	-	-	-	-	-	2
CO2	3	3	2	2	-	-	-	-	-	-	-	2
CO3	3	3	2	2	-	-	-	-	-	-	-	2
CO4	3	3	2	2	-	-	-	-	-	-	-	2

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Introduction to Probability and Statistics for Engineers and Scientists	Sheldon M. Ross	Academic Press	6th edition, 2021
2	Miller & Freund's Probability and Statistics for Engineers	Richard A. Johnson	Pearson	9th Global edition, 2018

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Statistical Methods	S.P. Gupta	Sultan Chand & Sons	46^{th} edition, 2021
2	Probability and Statistics for Engineering and the Sciences	Jay L. Devore	Cengage	9^{th} edition, 2016
3	Statistics for engineers and scientists	William Navidi	McGraw-Hill	6^{th} edition, 2023
4	Probability and Statistics for Engineers and Scientists	Walpole, Myers, Ye	Pearson	9^{th} edition, 2010

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL :: Mathematics - NOC:Introduction to Probability Theory and Stochastic Processes
2	NPTEL :: Mathematics - NOC:Introduction to Probability Theory and Stochastic Processes
3	NPTEL :: Mathematics - NOC:Introduction to Probability Theory and Stochastic Processes
4	NPTEL :: Mathematics - NOC:Introduction to Probability Theory and Stochastic Processes

SEMESTER S4

MOLECULAR BIOLOGY

Course Code	**PCBBT402**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To understand the overall structure and functions of DNA
2. To understand and evaluate the synthesis of protein and its structural modification
3. To study various types of mutations and its biological importance

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Concept of structure and function of DNA**. Identification of the genetic material – classical experiments, Griffiths, Avery, McLeod, Hershey and Chase. Central Dogma, Gene organization and distribution, Multi-gene families, Repetitive sequences with two examples, exon shuffling, Replication- Models of DNA Replication, enzymes involved in replication	**11**
2	**Transcription in prokaryotes and eukaryotes**: role of enzymes in transcription, major steps. Transcription initiation complex in prokaryotes and eukaryotes and its regulation. Post transcriptional processing of prokaryotic and eukaryotic transcripts.	**11**
3	**Outline the processes of prokaryotic and eukaryotic translation processes**. List out the basic components and steps needed to successful translation. Post translational modifications. Protein folding, HTH, HLH, Zinc finger motif. Molecular mechanism of gene regulation in prokaryotes-Transcriptional regulation in prokaryotes; Inducible & repressible system, positive & negative regulation; Operon concept, structure of operon, Lac, Trp, Catabolic repression, Atteunation, Multiple levels of eukaryotic gene regulation	**11**

4	**Overview of Mutation**, Types of Mutations mechanisms of mutation, DNA repair and types of repair DNA mismatches repair, direct and reversal. Nucleotide excision repair, double strand break repair and diseases arising from their defect. Recombination-molecular mechanisms of homologous recombination and non-homologous end joining in DNA. Alternative splicing, RNA editing, messenger nuclear exportation and coherence control, RNA interference, microRNA and regulation of mRNA stability.	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Remember the basic structure and biochemistry of nucleic acid discrimination between them	**K1**
CO2	Understand the relation between DNA replication, transcription and post transcriptional modifications	**K2**
CO3	Apply the the processes of prokaryotic and eukaryotic translation processes including the gene expression level	**K3**
CO4	Analyze the role of mutations and evaluate the effect of mutation in various human disorders	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2		2	2		2		2				2
CO2	3	2	2	3		2		2				2
CO3	2	3	2	2		2		2				2
CO4	3	2	3	3		2		2				2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cell and Molecular Biology	Wallace Marshall, Janet Iwasa, Gerald Karp		9th Edition
2	Essentials of Molecular Biology	Friefelder, David.	Panama Publishing 1993	2nd Edition
3	Molecular Cell Biolog	Lodysh H	Springer/Macmillan	9th Edition (2021)
4	Principles of Molecular Biology	Veer Bala Rastogi		

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Lewin's GENES XI		Jones & Bartlett Learning	11th Edition
2	Molecular Biology genes to Proteins	Tropp, Burton	Jones and Bartlett 2008	3rd Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Molecular Biology - Course (nptel.ac.in)
2	NPTEL :: Biotechnology - Molecular Cell Biology
3	Cell Biology: Cellular organization, division and processes - Course (nptel.ac.in)
4	NPTEL :: Biotechnology - Molecular Cell Biology

SEMESTER S4

FLUID FLOW AND PARTICLE TECHNOLOGY

(Group D)

Course Code	**PCBBT403**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Understanding of Bio-process Calculations (BBT205)	**Course Type**	Theory

Course Objectives:

1. To provide an insight into the fluid properties and the principles of fluid statics and kinematics.
2. To offer a prefatory on the momentum transfer principles with analysis of equations of change involved.
3. To elucidate and analyze the principles of flow of incompressible fluids in specific domains and flow past immersed particles in fluids.
4. To explicate the principles of flow measurement; transportation and metering of fluids, particle size measurement and particle size reduction.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to fluid mechanics** Definition of fluid, ideal and real fluids, Properties of fluids - Density, Specific weight, Specific Volume, Capillarity and Surface Tension, Viscosity, Vapour pressure. Absolute and Gauge Pressures. (Numerical problems) Fluid Statics-Forces on fluids and hydrostatic equilibrium, Measurement of Pressure using different types of manometers. Forces on submerged bodies, Stability of floating and submerged bodies. (Numerical problems)	11

2	Introduction to fluid flow- Flow of in-compressible 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. Reynold's Experiment, laminar flow, turbulent flow- characteristics and universal velocity distribution (Graphical representation and explanation needed but detailed analysis not required) **Equations of change for isothermal systems** Equations of change for isothermal systems - Equation of Continuity (Derivation is desired), its physical significance and vectorial representation, Qualitative treatment of Equation of Motion – Navier Stoke's Equation and Euler equation (derivations not required but significance is desired). Rheology of fluids, Newtonian and non- Newtonian fluids. Momentum flux and Newton's Law of Viscosity. Flow in boundary layers: Concept of drag and its types, Overview of boundary layer formation in pipe flow and for flow over flat plates; Concept of boundary layer separation and wake formation. Flow through pipe-Bernoulli equation (derivation required), Correction factors in Bernoulli equation (Derivation of equations not desired), Pump work – Numerical problems. Outline of pressure losses in straight pipes and in fittings (Numerical problems desired). Schedule number of pipes, concept of equivalent diameter.	11
3	**Flow of incompressible fluids & flow past immersed bodies** Flow of incompressible fluid in circular pipe: Laminar flow of Newtonian fluid-Hagen-Poiseullie equation (Derivation required); Shear stress and Velocity distribution in circular channel, relation between average and maximum velocity. Friction factor-Fanning and Darcy, Moody diagram. Transportation and metering of fluids: Classification of pumps, Characteristics of centrifugal pumps - Priming, cavitation, NPSH, water hammer, loss of head and power in centrifugal pumps (Numerical problems not required). Flow measurement - General equation for internal flow meters: Orifice meter and Venturimeter: Derivation of expression for flow rate using Bernoulli	14

	equation; Weirs: Classification and derivation of equations for flow rate in rectangular and triangular notches, concept of area meters: Rotameter; Local velocity measurement: Pitot tube: Principle and equations. Resistance of immersed bodies - Concept of drag and drag coefficient; variation of drag coefficient with particle Reynolds number. Free settling-motion of particle under gravitational and centrifugal fields, terminal settling velocity and Stoke's law (Derivation of the equation using force balance is required), Hindered Settling.	
4	**Particle Technology** Describing the size of a single particle- Sphericity and shape factor, Particulate solids-various mean diameters. Particle size analysis- Sieving, Laser diffraction, Dynamic light scattering, Nano particle tracking analysis, Sub-sieve auto sizer, Elutriation. Solid liquid separation-Filtration, centrifugation, sedimentation and decantation, flocculation (Detailed analysis using equations not desired). Particle size reduction – Introduction of comminution theory and associated laws, comminution mechanism, classification of size reduction equipment, factors affecting choice of equipment. Particle size enlargement: Mechanism, Inter-particle forces and granulation.	**8**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Summarize the fluid properties and forces on fluids at rest and motion.	**K2**
CO2	Demonstrate governing laws of momentum transport and energy balance equations in specific domains of frictional flow/boundary layer flow of fluids and in potential flow.	**K3**
CO3	Apply the principles of flow measurement in different flow metering equipment and in fluid transport using pumps .	**K3**
CO4	Summarize the particle size analysis methods, mechanism of size reduction of solids, and solid- liquid separation processes.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										2
CO2	3	2										2
CO3	3	2										2
CO4	3	2										2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Unit Operations of Chemical Engineering,	McCabe, W.L., J.C. Smith and P.Harriot	Mc Graw Hill	6^{th} Edition,2001
2	Chemical Engineering: Particle technology and Separation processes	Coulson J. M and J. F Richardson	Butterworth-Heinemann	Vol - II, 5^{th} Edition, 1999
3	Transport Processes and Separation Process Principles	Geankoplis, C.J	Pearson	5th Edition, 2015.

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Chemical Engineering: Fluid flow, Heat transfer and Mass transfer	Coulson J. M and J. F Richardson	Butterworth-Heinemann	V*ol - II,* 5^{th} Edition, 1999
2	Introduction to ParticleTechnology	Martin J. Rhodes	John Wiley & Sons	2^{nd} Edition, 2008
3	Perry's Chemical Engineer's Handbook	Perry R. H. and D.W. Green	McGraw Hill	7^{th} Edition, , 1997
4	Mechanical Operations For Chemical Engineers: Incorporating Computer Aided Analysis	Narayanan C.M. & Bhattacharya B.C	Khanna Publishers	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/104/103104044/
2	https://archive.nptel.ac.in/courses/103/104/103104044/
3	https://archive.nptel.ac.in/courses/103/104/103104044/
4	https://archive.nptel.ac.in/courses/103/106/103106103/

SEMESTER S4

ELEMENTS OF CHEMICAL AND BIOLOGICAL REACTION ENGINEERING

(Group D)

Course Code	PBBBT404	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Understanding of Bio-process Calculations (BBT205)	Course Type	Theory

Course Objectives:

1. To provide a comprehensive introduction to the fundamentals of chemical and biological reaction engineering, focusing on reaction kinetics and their mathematical descriptions.
2. To equip students with the skills to analyse and design both batch and continuous reactors, understanding their behaviour and performance.
3. To impart knowledge on the dynamics of ideal, non-ideal, non-isothermal, and non-homogeneous reaction systems, ensuring a thorough understanding of their practical applications.
4. To introduce the principles of heterogeneous catalytic reactions, including the mechanisms and design of industrial catalytic reactors.
5. To develop problem-solving skills through numerical analysis of reaction rates, reactor design, and interpretation of experimental data, preparing students for real-world chemical and biological engineering challenges.

SYLLABUS

Module No	Syllabus Description	Contact Hours
1	An overview of chemical & biological reaction engineering. Definition of reaction rate. Basic concepts of chemical kinetics. Classification of chemical reactions. Temperature & concentration dependency of reaction rate- Arrhenius theory, Collision Theory - Numerical Problems for evaluation of activation energy	9

	Analysis of rate equations –Interpretation of batch reactor data: integral (first order irreversible and reversible, second order irreversible, series and parallel reactions only need to be addressed), differential method and half-life method of rate analysis. Numerical problems on determination of rate equations based on integral method of analysis.	
2	Introduction to reactor design-Classification of reactors. Concept of Ideal reactors. Design equations for batch, mixed flow and plug flow 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. (Numerical problems for evaluation of reactor volume, conversion) Non isothermal reactor design- Heat effects in reactors- Effect of temperature on Specific heat and heat of reaction. General graphical design procedure- Optimum temperature progression	**9**
3	Basics of non-ideal flow-Residence time distribution. Measurement of the RTD-Pulse and step input - C, E, F curves-RTD in ideal reactors. Moments of RTD – Mean and Variance Single parameter models of RTD- Tanks in Series and Dispersion model - Derivations are required. (Quantitative treatment by solving Numerical problems on plotting RTD curves and moments of RTD	**9**
4	Kinetics of cell growth: substrate uptake and product formation in microbial growth, Michaelis-Menten rate form, Determination of M-M parameters. Biological reactors – chemostats and plug flow tubular reactors, Monod-	**9**

	chemostat model. (Numerical problems for finding out the substrate and biomass concentrations are expected) Heterogeneous catalytic processes- classification of catalysts, promoters, inhibitors and poisons. Different steps involved in rate equations of fluid-solid catalytic-reactions Commercially significant types of heterogeneous catalytic reactors – Packed bed reactors, Fluidised bed reactors and Slurry Reactors. (No numerical problems or derivations are expected from the Heterogeneous reactions)	

Project-Based Learning (8 Hours)

1. **Group Formation and Project Selection**:
    - Students will be divided into groups and allowed to select a simple chemical or biological reaction system suitable for the course objectives. (Should be done immediately after the introductory class).
    - An initial project proposal outlining the selected reaction system, the type of reaction, the reactors involved, and the project scope.
2. **Module-I: Kinetics and Reaction Rates**
    - Determination of Kinetics and Reaction Rate of the identified reaction
        - Define the reaction rates for the selected system.
        - Perform a literature review on the temperature and concentration dependency of the reaction rates using Arrhenius and Collision theories.
        - Collect experimental data or use provided data to evaluate the activation energy and other kinetic parameters.
    - A detailed report on reaction kinetics, including the evaluation of activation energy and determination of rate equations.

3. **Module-II: Reactor Design**
    - Calculating the volume of the reactor required
        - Classify and describe the types of reactors relevant to the project.
        - Develop design equations for single ideal reactors and multiple reactor systems to determine the best system for a given conversion.
        - Explore non-isothermal reactor design by developing the temperature profile leading to reactor design.
    - A reactor design report with detailed calculations and justifications for the chosen reactor configurations.
4. **Modeling and Software Analysis**:
    - Simulation studies using software
        - Model the selected reaction system and reactors using appropriate chemical engineering software.
        - Compare the manual design and calculations with the software-generated results.
    - A final project report that includes all analysis, designs, and software modeling results. Highlight any discrepancies and provide possible explanations and solutions.
5. **Presentation and Submission**:
    - Prepare a presentation summarizing the project, including key findings, design choices, and comparison between manual and software results.
    - Submit the final project report and presentation to the faculty.

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 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 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Estimate the kinetics for chemical and biological reactions	**K3**
CO2	Analyze the performance of Batch and Continuous reactors and recommend modifications for improvement	**K4**
CO3	Predict the conversion for ideal and non-ideal reactors	**K3**
CO4	Explain the nature of catalytic reactions with regard to the multiple steps of mass transfer and surface reaction and the concept of rate limiting step	**K2**
CO5	Design chemical and biological reaction systems for academic learning or addressing real community issues. service.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	3	2	2	2	1	-	-	-	-	-
CO2	3	2	2	1	2	3	3	3	2	2	2	2
CO3	3	2	2	2	2	2	2	3	2	2	2	2
CO4	3	2	1	1	2	3	3	-	-	-	-	-
CO5	3	2	2	2	2	3	3	3	2	2	2	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Chemical Reaction Engineering	Octave Levenspiel	Wiley Student Edition	Third, 2021
2	Bioprocess Engineering Principles	Pauline M Doran	Elsevier- Academic Press	Second, 2013
3	Chemical Engineering Kinetics	J M Smith	McGraw Hill International	Third, 1981

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Essentials of Chemical Reaction Engineering	H Scott Fogler	Pearson Education	Second, 2020
2	Biochemical Engineering Fundamentals	J E Bailey, D F Ollis	McGraw-Hill Chemical Engineering Series	Second, 2017
3	Introduction to Chemical Engineering Kinetics & Reactor Design	Hill C G, Root T W	John Wiley	Second, 2014
4	Chemical Reaction Engineering - Essentials, Exercises and Examples	Martin Schmal	CRC Press	First, 2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1, 2, 3, &4	https://archive.nptel.ac.in/courses/103/103/103103153/ https://nptel.ac.in/courses/103106116 http://acl.digimat.in/nptel/courses/video/103103153/L01.html

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

- Active participation and individual contribution
- Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**
   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**
   - Quality and clarity of the overall presentation
   - Individual contribution to the presentation
   - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**
   - Overall quality and technical excellence of the project
   - Innovation and originality in the project
   - Creativity in solutions and approaches

SEMESTER S4

PLANT AND ANIMAL CELL TECHNOLOGY

Course Code	**PEBBT411**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To inculcate the knowledge regarding the cell culture systems and culturing techniques
2. To appreciate the industrial applications of the culturing techniques in the various field of biotechnology

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to plant tissue culture:**History of plant tissue culture, micropropagation, aseptic conditions, media used in plant tissue culture, role of plant growth regulators, cell suspension cultures, Importance of haploids and triploids in plant tissue culture **Hybridization** -Somatic hybridization and cybridization, **Preservation of cells**- Cryopreservation in plant tissue culture	**9**
2	**Different types of plant tissue culture**- Callus cultures, Meristem cultures, Anther culture, Embryo culture, Protoplast culture, Somaclonal variation, synthetic seeds. Methods of plant tissue preservation and applications. **Production of transgenic plants**. Development of herbicide resistance- glyphosate, phosphinothricin, sulfonylurea, atrazine resistant transgenic plants. **Gene transfer techniques in plants**- Agrobacterium tumefaciens mediated transfer- techniques of transferring agronomically important genes using Ti plasmid, Ri plasmid.	**9**
3	**Cell culture:** Basic techniques of mammalian cell culture *in vitro*; disaggregation of tissue, primary culture establishment; maintenance of cell culture. **Cell lines**- characteristics and routine maintenance. Measurement of viability and cytotoxicity.	**9**

	Cultured cells- Biology and characterization: Characteristics of cultured cells, Measurement of growth parameters of cultured cells, Cell adhesion, Cell proliferation and differentiation, Identification of specific cell lines	
4	**Animal tissue culture:** Laboratory design, aseptic conditions, methodology and media; Equipment and materials for animal cell culture technology, Balanced salt solution and simple growth medium. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Role of serum and supplements. Serum &protein-free defined media and their applications; **Organ and histotypic cultures**, three-dimensional culture -, applications of animal cell culture-. **Application of animal cell culture** : Improvements of animals using transgenic approach with specific examples Animals as bioreactors.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the basics about cell culture and its various parameters	**K2**
CO2	Summarize on various plant and animal tissue culture systems and their establishment	**K2**
CO3	Apply the concepts of plant &animal cell culture systems and its various approaches for the industrial production strategies	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	2					3					3
CO2	2	2					3	2				3
CO3	2	2					3	2				3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Culture of animal cells	Freshney, R.I	John Wiley	2005
2	Introduction to plant biotechnology	H S Chawla	Science Publishers	2002
3	Basic cell culture: A practical approach	J M Davis	Oxford University Press	
4	Plant Biotechnology: New products and applications	Hammond J, MacGrarvey P, Yusibov V	Springer	2002

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Culture of Animal cells: A manual of Basic techniques and specialized applications	Rian Freshney	Wiley-Blackwell	2010
2	Animal cell culture: A practical approach	John R W Masters	Oxford University Press	2000
3	Introduction to plant tissue culture	M K Razdan	Science Publishers	2003
4	Genetic transformation of plants	Jackson J F, Linskens H F	Springer	2003

Video Links (NPTEL, SWAYAM…)	
Module No.	Link ID
1	nptel.ac.in/courses/102/103/102103016
2	nptel.ac.in/courses/102/103/102103016
3	.nptel.ac.in/courses/102/104/102104059/
4	.nptel.ac.in/courses/102/104/102104059/

SEMESTER S4

FOOD PROCESS TECHNOLOGY

Course Code	PEBBT412	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 min.
Prerequisites (if any)	Knowledge of Microbiology required	Course Type	Theory

Course Objectives:

This course aims to prepare the students

1. To know about the constituents and additives present in the food.
2. To gain knowledge about the microorganisms, which spoil food and food borne diseases.
3. To know different techniques used for the preservation of foods.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Food Process Technology Food processing, Nutritional values of food, Use of enzymes in food industry, Factors affecting growth and survival of microorganisms in food, Single cell protein, genetically modified food, Fermented food products, Dairy products, Fermented milk, Cheese, Butter, Fermented Meat, Fermented fish	9
2	Food Microbiology Microbiology of milk & milk products like cheese, butter, ice-cream, milk powder; Microbiology of meat, fish, poultry & egg and their products. Food spoilage, Bacterial agents of food borne illness- Clostridium, Salmonella, Vibrio, Non-bacterial agents of food borne illness - Helminthes, protozoa, Algae, Fungi, Viruse	9
3	Food Preservation Role of chemicals and enzymes in food preservation, Biochemical engineering for flavor and food production, Microbiology of food preservation-physical, chemical and biological based preservation system, Canning: Preservation principle of canning of food items.	9

4	Food Safety Issues and new biotechnologies Food standards, safety evaluation of novel food products, genetically modified microorganisms and their products, genetically modified plants and their products, genetically modified animals and their products, detection methods of GM crops	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the role of biotechnology in food processing and fermented food production.	**K2**
CO2	Analyse the various types of microorganisms used in the food products	**K4**
CO3	Delineate food safety issues and new biotechnologies bacterial, plant and animal products.	**K5**
CO4	Apply the knowledge of unit operations in modern food processing in industries	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3		2								**2**
CO2	3	3	2		2							2
CO3	3	3	2				2					2
CO4	3	3										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Food-The Chemistry of its Components	T.P.Coultate	2nd edition. Royal society, London, 1992	1992
2	Food processing and preservation	B.Sivasanker	Prentice-Hall of IndiaPvt.Ltd.New Delhi, 2002	2002
3	Basic Food Microbiology,	George JB	CBS Publishers & Distributors, 1987	1987

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Food Microbiology	W.C.Frazier and D.C.Westhoff	4th Ed.,McGraw-Hill book Co.,New York.	
2	Modern Food Microbiology	.J.M.Jay	, CBS Pub.New Delhi,1987.	1987

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_ag03/preview
2	https://onlinecourses.nptel.ac.in/noc23_ge32/preview
3	https://archive.nptel.ac.in/courses/126/105/126105015/
4	https://archive.nptel.ac.in/courses/103/107/103107088/

SEMESTER: S4

BIOENERGY AND BIOFUELS

(Biotechnology/Biotechnology & Biochemical Engineering)

Course Code	**PEBBT413**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To provide an insight on the various biological processes for energy production.
2. To review the state of the art, design and economics, and future prospects of various current and emerging processes for bioenergy and biofuels production.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to bioenergy**: Policies and initiatives (global and national), energy perspective, renewable feedstock for bioenergy production, their availability and characteristics, energy yields from conversion of energy crops to biofuels:, energy content of biofuels, challenges in applying sustainable bioenergy systems and their further development.	9
2	**Bioethanol**: Basic principles, biological kinetics and yields, yield improvements, process design of a bioethanol plant, feedstock, crop improvements, value-added co-products and downstream processes for product recovery, state of the art and emerging applications, prospects and challenges, and environmental implications. **Crop oils, biodiesel and algal biofuels:** Vegetable oils-composition, extraction, production and use, use of vegetable oil as an alternative diesel fuel, growth, screening and harvesting of microalgae, algal oil extraction, properties of biodiesel, manufacture of biodiesel, prospects and economics of biodiesel production.	9

3	**Biohydrogen**: Prospects of biohydrogen as a potential energy resource, basic principles, biohydrogen production processes, dark and photofermentation, biological kinetics and yields-strategies to improve process efficiency, major challenges, cell engineering and emerging applications-design, life cycle analysis and environmental implications. **Biomethane**: Biogas and biomethane as high value renewable energy sources - properties, advantages and disadvantages, feedstock and production processes, yields and yield improvements, methane production in landfills and its capture, Biogas digesters- design features and working principle.	**9**
4	**Bioelectrical systems**: Microbial fuel cells, microbial electrolysis cells, other bioelectrical systems-basic principles, state of the art processes, efficiency enhancement and environmental implications, emerging bioelectrical systems. **Life cycle analysis and sustainability of bioenergy systems**: Social, environmental and economic impacts of biofuels, feedstock costs, capital costs, operating costs, food versus fuel debate, case studies of biohydrogen, bioethanol, and biodiesel production.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Outline the various types of biofuels and bioenergy systems.	**K2**
CO2	Discuss the processes for commercial production of liquid and gaseous biofuels.	**K2**
CO3	Practice life cycle analysis (LCA) in the context of techno-economic feasibility and sustainability of biofuels and bioenergy systems.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											2
CO2	2											2
CO3	3	2		2			3					2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biofuels and bioenergy: processes and technologies	Sunggyu Lee Y.T. Shah	CRC Press	1st edition, 2013
2	Bioenergy: principles and applications	Yebo Li, Samir Kumar Khanal	Wiley Blackwell	1st edition, 2017
3	Introduction to bioenergy	Vaughn Nelson Kenneth Starcher	CRC Press	1st edition, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioenergy: biomass to biofuels and waste to energy	Anju Dahiya	Academic Press	2nd edition, 2020
2	Sustainable bioenergy production	Lijun Wang	CRC Press	1st edition, 2014
3	Sustainable bioenergy: advances and impacts	Mahendra Rai Avinash P. Ingle	Elsevier	1st edition, 2019
4	Bioenergy systems for the future: prospects for biofuels and biohydrogen	Fransesco Dalena Angelo Basile Claudio Rossi	Woodhead Publishing	1st edition, 2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/fR0chD3Ob1M
2	https://youtu.be/FuBVMVct1M4 , https://youtu.be/GS3awC0BVLE
3	https://youtu.be/qaMDiT6iEBQ, https://youtu.be/vey0H0C1NrQ
4	https://youtu.be/YAbrNJ3WwuU https://youtu.be/AZK3IXNC6pk?list=PLyqSpQzTE6M-ZgdjYukayF6QevPv7WE-r, https://youtu.be/iVmqUrqqhuU?list=PLyqSpQzTE6M-ZgdjYukayF6QevPv7WE-r

SEMESTER S4
BIOCHEMICAL THERMODYNAMICS

(Common to Biotechnology Engineering (BT) and Biotechnology & Biochemical Engineering (BB) Branches/D Group/Groups)

Course Code	**PEBBT414**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. This course is aimed at providing a complete insight into the basic theory of thermodynamics and its implications in process engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of Thermodynamics Systems**, Open system and closed system, State and path function, Zeroth law of thermodynamics, Reversible and irreversible processes, First law of thermodynamics, Internal Energy, Enthalpy, Flow processes, Concept of Entropy and second law of thermodynamics, Third law of thermodynamics	9
2	**Thermodynamic Properties of Pure fluids and Phase Equilibria** Thermodynamic properties and their relationships, Maxwell's equations, Gibbs-Helmholtz equation, Behavior of ideal gases, Properties of gases showing non-ideal behaviour, Phase rule, Vapour-liquid equilibrium, Liquid-liquid equilibrium	9
3	**Properties of Solutions and Chemical Reaction equilibria** Fugacity of pure gases, liquids and solids, Partial Molar properties, Chemical Potential, Solution thermodynamics, Homogeneous chemical reactions, Effect of pressure and temperature on equilibrium constant, Activity coefficient, Ionic equilibria, Dissociation equilibria of acids and bases, Henry's law, Properties of fluids, Gibbs free energy, Entropy and heat capacity relation, Colligative properties	9

4	**Thermodynamics in Biochemical Processes** Thermodynamics and energetics of metabolic pathways, Free energy transfer of amino acids, Protein stability and protein dynamics, Membrane transport, Protein folding and pathological misfolding, Interaction free energy, Thermodynamics of oxidation-reduction reactions, Energetics of DNA-protein Interactions	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understanding of thermodynamics laws and properties	**K1**
CO2	Examine the behaviour of gases and analyse the concept of phase equilibria	**K2**
CO3	Apply the concepts of solution thermodynamics and various reaction equilibria	**K3**
CO4	Utilize thermodynamics to assess and resolve challenges in biological systems	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2			1						1
CO2	3	2	2			1						1
CO3	3	3	2			1						1
CO4	3	3	2			1						1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Textbook of Chemical Engineering Thermodynamics	Narayanan, K. V	India, PHI Learning	2013
2	Chemical and Engineering Thermodynamics,	Sandler S. I	John Wiley	1989
3	Engineering and Chemical Thermodynamics,	Koretsky M. D.,	John Wiley	2004

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Atkins' Physical Chemistry: Thermodynamics and Kinetics ,	Atkins, Peter William, et al	. United Kingdom, Oxford University Press	2018
2	Principles of Physical Chemistry, ,	B.R. Puri, L.R. Sharma and M.S. Pathania	Vishal Publishing Co	2017.
3	Biological Thermodynamics. 2014.	Haynie, Donald Templeton.	United Kingdom, Cambridge University Press,	2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	onlinecourses.nptel.ac.in/noc21_bt03/preview
2	ttps://archive.nptel.ac.in/courses/102/105/102105064/
3	onlinecourses.nptel.ac.in/noc21_bt03/preview
4	'Biochemical Engineering' Video Lectures from IIT Kharagpur by Dr. Saikat Chakraborty, Dr. Rintu Banerjee - Chemical Engineering NPTEL Video Lectures (nptelvideos.com)

SEMESTER S4

BIOMATERIALS & TISSUE ENGINEERING

(Biotechnology/Biotechnology & Biochemical Engineering)

Course Code	**PEBB416**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To acquire an insight about the uses of common biomaterials such as metals, ceramics and polymers, and their chemical structure, properties, and morphology.
2. To illustrate the nature of cell-biomaterial interactions and the fundamental processes relevant to cell physiology.
3. To provide an overview of the fundamental concepts of tissue engineering, with the aid of suitable case studies.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Properties of materials**: Bulk properties and surface properties of materials, characterization methods of surface properties of biomaterials. **Materials used in medicine**: Metals; polymers; hydrogels; bioresorbable and biodegradable materials, fabrics; biologically functional materials; ceramics; natural materials; composites, thin films, grafts and coatings; pyrolytic carbon for long-term medical Implants; porous materials; nano-biomaterials.	**9**
2	**Host reactions to biomaterials**: Inflammation; wound healing and the foreign body response; systemic toxicity and hypersensitivity; blood coagulation and blood-materials interactions; tumorigenesis. **Degradation of materials in biological environment**: Degradation of polymers, metals and ceramics.	**9**

3	**Introduction to tissue engineering**: Structure and organization of tissues- Epithelial, connective; vascularity and angiogenesis, cell migration, current scope of development and use in therapeutic and in-vitro testing, scientific challenges. **Aspects of Cell culture**: Different cell types, progenitor cells and cell differentiations, different kind of matrix, cell-cell interaction; cell expansion, cell transfer, cell storage and cell characterization, cell culture bioreactors.	**9**
4	**Molecular biology aspects**: Cell-signalling molecules, growth factors, hormone and growth factor signalling, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, Cell-surface markers. **Scaffold and transplant**: Engineering biomaterials, Degradable materials, porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Case studies and regulatory issues-cell transplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Outline the different classes of biomaterials and their applications in medical/ tissue engineering context.	**K2**
CO2	Explain cell-biomaterial interactions and the major physiological processes relevant to transplantation medicine and tissue engineering.	**K2**
CO3	Summarize the strategies for engineering of tissues for replacement of various organs of the body.	**K3**
CO4	Outline the technical challenges and ethical/regulatory issues underlying the applications of tissue engineering.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										2
CO2	1	2										2
CO3	2	2										2
CO4	1	2				3		3				2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomaterials and Tissue Engineering	Donglu Shi	Springer	1st edition, 2004
2	Biomaterials: an introduction	Joon Park R.S. Lakes	Springer	3rd edition, 2007
3	Tissue Engineering	Bernhard O. Palsson Sangeeta N. Bhatia	Pearson	1st edition, 2009
4	Principles of tissue engineering	Robert Lanza Robert Langer Joseph Vacanti	Academic Press	4th edition, 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biomaterials science: an introduction to materials in medicine	Buddy D. Ratner Allan S. Hoffman Frederick J. Schoen Jack E. Lemons	Elsevier	2nd edition, 2004
2	The biomedical engineering handbook	Joseph. D. Bronzino Donald. R. Peterson	CRC Press	4th edition, 2015
3	Tissue engineering: principles and practices	John. P. Fisher Antonios. G. Mikos Joseph. D. Bronzino Donald. R. Peterson	CRC Press	1st edition, 2013
4	Biomaterials for organ and tissue regeneration: new technologies and future prospects	Nihal Engin Vrana Helena Knopf-Marques Julien Barthes	Woodhead publishing	1st edition, 2020

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_bt28/preview ttps://archive.nptel.ac.in/courses/113/104/113104009/
2	
3	
4	

SEMESTER: S4

ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY

(Biotechnology/Biotechnology & Biochemical Engineering)

Course Code	**PEBBT415**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

To enable the students

1. To have a fundamental knowledge about the electrophoretic and spectroscopic techniques
2. To acquire knowledge on the different chromotographic methods for separation of biological products.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Electrophoretic Techniques** Principles and instrumentation of Gel electrophoresis (for DNA and Proteins); Isoelectric focusing; Two-dimensional gel electrophoresis; Pulse field gel electrophoresis; Western blot, Southern blot	**9**
2	**Spectroscopic Techniques** Introduction to absorption and emission spectroscopy: Theory (Beer-Lambert's law) and instrumentation of single beam and double beam UV-visible spectrophotometers, calibration and standardization; Theory and instrumentation of fluorescence and phosphorescence spectrometry; Flame emission and atomic absorption spectroscopy; Infrared spectrometry: FTIR; Raman spectroscopy.	**9**
3	**Chromatography and Structure analysis** Gas chromatography and HPLC; Flow Cytometry; Mass spectrometry: Ionization and fragmentation, Basics of LC/MS & GC/MS, Tandem mass spectrometry; X-ray diffraction crystallography; Nuclear magnetic resonance	**9**

	spectrometry; Circular Dichroism; Thermal analysis techniques.	
4	**Electro Analysis and Surface Microscopy** Electrochemical cells- Electrode potential cell potentials – potentiometry-reference electrode – ion selective and molecular selective electrodes – Instrument for potentiometric studies – Voltametry – Cyclic and pulse voltametry- Applications of voltammetry . Study of surfaces – Scanning probe microscopes – AFM and STM.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyze and identify suitable analytical techniques for quantification of biological macromolecules	**K4**
CO2	Apply the working principles of electrophoretic, spectroscopic, chromatographic and microscopic techniques for molecular characterization	**K3**
CO3	Interpret the data procured from the molecular characterization and provide appropriate structural and functional details	**K5**
CO4	Design series of experiments involving various techniques for purification and analysis of proteins, lipids, DNA and carbohydrates.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2									2
CO2	3	2	2									2
CO3	3	2	2		2							2
CO4	3	2	2		2	3		3				2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Wilson and Walker's principles and techniques of biochemistry and molecular biology.	Wilson, K., Hofmann, A., Walker, J. M., & Clokie, S.	Cambridge university press.	2018
2	Modern Optical Spectroscopy: From Fundamentals to Applications in Chemistry, Biochemistry and Biophysics.	Parson, W. W., & Burda, C.	Springer.	2022
3	Biomolecular and bioanalytical techniques: theory, methodology and applications.	Ramesh, V.	John Wiley & Sons.	2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Immunoassay and other bioanalytical techniques.	Van Emon, J. M. (Ed.).	CRC Press.	2016
2	Methods of molecular analysis in the life sciences.	Hofmann, A., Simon, A., Grkovic, T., & Jones, M.	Cambridge University Press.	2014
3	Optical spectroscopic and microscopic techniques.	Sahoo, H.	Springer Singapore.	2022

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/102/107/102107028/
2	https://archive.nptel.ac.in/courses/102/103/102103044/
3	
4	https://onlinecourses.nptel.ac.in/noc22_bt60/preview

SEMESTER S4

ECONOMICS FOR ENGINEERS

(Common to All Branches)

Course Code	**UCHUT346**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function	6

2	Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm)	**6**
3	Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation Taxation – Direct and Indirect taxes (merits and demerits) - GST National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators- SENSEX and NIFTY	**6**
4	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 - Cost-Benefit Analysis - Capital Budgeting - Process planning	**6**

Course Assessment Method
(CIE: 50 marks , ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Case study/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
10	15	12.5	12.5	50

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• Minimum 1 and Maximum 2 Questions from each module. • Total of 6 Questions, each carrying 3 marks **(6x3 =18marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. **(4x8 = 32 marks)**	**50**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function.	**K2**
CO2	Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations.	**K3**
CO3	Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market.	**K2**
CO4	Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting techniques.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	-	-	-	-	-	1	-	-	-	-	1	-
CO2	-	-	-	-	-	1	1	-	-	-	1	-
CO3	-	-	-	-	1	-	-	-	-	-	2	-
CO4	-	-	-	-	1	1	-	-	-	-	2	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managerial Economics	Geetika, Piyali Ghosh and Chodhury	Tata McGraw Hill,	2015
2	Engineering Economy	H. G. Thuesen, W. J. Fabrycky	PHI	1966
3	Engineering Economics	R. Paneerselvam	PHI	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Engineering Economy	Leland Blank P.E, Anthony Tarquin P. E.	Mc Graw Hill	7TH Edition
2	Indian Financial System	Khan M. Y.	Tata McGraw Hill	2011
3	Engineering Economics and analysis	Donald G. Newman, Jerome P. Lavelle	Engg. Press, Texas	2002
4	Contemporary Engineering Economics	Chan S. Park	Prentice Hall of India Ltd	2001

SEMESTER S3/S4
ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

Course Code	**UCHUT347**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	2:0:0:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of ethics** - Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places**-accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**. **Basic concepts in Gender Studies** - sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, employment and everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in connection with**	**6**

	gender - equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.**	
2	**Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure.	**6**
3	**Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions.	**6**
4	**Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and	**6**

	regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future.	

Course Assessment Method
(CIE: 50 marks , ESE: 50)

Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

Sl. No.	Item	Particulars	Group/Individual (G/I)	Marks
1	Reflective Journal	Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts.	I	5
2	Micro project (Detailed documentation of the project, including methodologies, findings, and reflections)	1 a) Perform an Engineering Ethics Case Study analysis and prepare a report 1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics	G	8
		2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context	G	5
		3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV	G	12
3	Activities	2. One activity* each from Module II, Module III & Module IV	G	15
4	Final Presentation	A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings.	G	5
		Total Marks		**50**

*Can be taken from the given sample activities/projects

Evaluation Criteria:

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop the ability to apply the principles of engineering ethics in their professional life.	**K3**
CO2	Develop the ability to exercise gender-sensitive practices in their professional lives	**K4**
CO3	Develop the ability to explore contemporary environmental issues and sustainable practices.	**K5**
CO4	Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience.	**K4**
CO5	Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	2	3	3	2		2
CO2		1				3	2	3	3	2		2
CO3						3	3	2	3	2		2
CO4		1				3	3	2	3	2		2
CO5						3	3	2	3	2		2

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ethics in Engineering Practice and Research	Caroline Whitbeck	Cambridge University Press & Assessment	2nd edition & August 2011
2	Virtue Ethics and Professional Roles	Justin Oakley	Cambridge University Press & Assessment	November 2006
3	Sustainability Science	Bert J. M. de Vries	Cambridge University Press & Assessment	2nd edition & December 2023
4	Sustainable Engineering Principles and Practice	Bhavik R. Bakshi,	Cambridge University Press & Assessmen	2019
5	Engineering Ethics	M Govindarajan, S Natarajan and V S Senthil Kumar	PHI Learning Private Ltd, New Delhi	2012
6	Professional ethics and human values	RS Naagarazan	New age international (P) limited New Delhi	2006.
7	Ethics in Engineering	Mike W Martin and Roland Schinzinger,	Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi	4" edition, 2014

Suggested Activities/Projects:
Module-II

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

Module-III

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater

harvesting, and how to decrease the supply-demand ratio

- Implement a zero waste initiative on the college campus for one week and document the challenges and outcomes.
- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

Module-IV

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

SEMESTER S4

MOLECULAR BIOLOGY LAB

(Common to Biotechnology & Biochemical Engineering (BB) and Biotechnology Engineering (BT) Branches/ D Group)

Course Code	**PCBBL407**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0-0-3-0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Lab

Course Objectives:

1. Provide hands-on experience in performing basic molecular biology and genetic engineering techniques.
2. Introduce the theory behind each technique and describe common applications of each methodology in biological research. This will facilitate the students to take up specialized projects in Molecular biology and will be a pre-requisite for research work.

Expt. No.	Experiments
1	Isolation of plasmid from *Escherichia coli (E.coli)*
2	Isolation of genomic DNA from eukaryotes
3	Isolation of mRNA from eukaryotes and cDNA synthesis
4	Transformation of *E.coli.*
5	Competent cell preparation and Transformation of yeast.
6	Selection of recombinants (blue-white screening).
7	Isolation of DNA fragments by restriction digestion
8	DNA ligation of isolated genes
9	Restriction mapping of plasmids/vectors
10	Gel elution of DNA fragments
11	DNA Quantification by Spectrophotometric method, Fluorescence dyes mediated method, and Diphenylamine method
12	Protein Electrophoresis Using SDS-PAGE
13	Protein Gel Staining method

14	Western blotting
15	Gene expression analysis using RT PCR (Demonstration)
16	Southern hybridization of a cloned fragment

Course Assessment Method (CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the techniques of DNA isolation and manipulation from any biological sources	**K1**
CO2	Generate and analyze the restriction pattern of DNA molecules.	**K1, K2**
CO3	Evaluate the phenotypic analysis of transformed yeast and bacteria with plasmid DNA	**K3**
CO4	Evaluate the amplified DNA fragments.	**K4**
CO5	Design, comprehend, and assess any DNA molecules.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2					2	2	2	2
CO2	3	2		2	2	2	2	1	2	2	2	2
CO3	3	3	2	2					2	2	2	2
CO4	3	3	2	2				1	2	2	2	2
CO5	3	3	2		2			2	2	2	2	2

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Molecular Biology Techniques: A Classroom Laboratory Manual	Sue Carson, Heather Miller, Melissa Srougi, D. Scott Witherow,	Fourth Edition, Academic Press, Elsevier, 2019	Fourth Edition, Academic Press, Elsevier, 2019
2	Calculations for Molecular Biology and Biotechnology	Frank H. Stephenson	Third Edition, Academic Press, Elsevier, 2016.	Third Edition, Academic Press, Elsevier, 2016.
3	Molecular Cloning: A Laboratory Manual	Michael R. Green and Joseph Sambrook	Fourth Edition, Cold Spring Laboratory Press, 2012.	Fourth Edition, Cold Spring Laboratory Press, 2012.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles and Techniques of Biochemistry and Molecular Biology	Keith Wilson and John Walker	8th Edition, Cambridge University Press, 2018	8th Edition, Cambridge University Press, 2018
2	Molecular Biology Problem Solver-A Laboratory Guide	Alan S. Gerstein,	Wiley-Liss, Inc., 2017	Wiley-Liss, Inc., 2017
3	Molecular Biology of the Gene,	J. D. Watson, T. A. Baker, S. P. Bell, and A. Gann	6th Edn., Benjamin Cummings, 2007	6th Edn., Benjamin Cummings, 2007

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S4

FLUID FLOW & PARTICLE TECHNOLOGY LAB

Course Code	PCBBL408	CIE Marks	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	ESE Marks	50
Credits	2	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Lab

Course Objectives:

1. Enhance practical skills with momentum transfer mechanisms in industrial bio processing

Expt. No.	Experiments
1	Study of measurement of pressure.
2	Use of viscometers for measurement of viscosity of process fluids.
3	Study on factors influencing viscosity of process fluids.
4	Reynold's Experiment.
5	Particle size analysis by Sieve analysis.
6	Sub sieve particle size analysis using Beaker decantation.
7	Sub sieve particle size analysis using Pipette Analysis.
8	Studies on flocculation- Analysis of orthokinetic and perikinetic aggregation.
9	Determination of drag coefficient and verification of Stoke's law.
10	Determination of venturi coefficient/ orifice coefficient.
11	Calibration of Rotameter for liquid flows.
12	Determination of velocity profile using Pitot tube.
13	Estimation of pressure drop for flow through packed bed.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Demonstrate fluid properties and particle size distribution	**K1**
CO2	Demonstrate Reynold's experiment and drag coefficient apparatus	**K1, K2**
CO3	Demonstrate discharge coefficient and calibration curve of flow measuring equipments	**K3**
CO4	Design experiments and analyze data collected from experimental investigation	**K4**
CO5	Apply modern computing tools necessary for analysis of the experimental data	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2			2		2	2	2		
CO2	3	3	2			2		2	2	2		
CO3	3	3	2			2		2	2	2		
CO4	3	3	2			2		2	2	2		
CO5	3	3	2		2	2		2	2	2		

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Unit Operations of Chemical Engineering,	McCabe, W.L., J.C. Smith and P.Harriot	Mc Graw Hill	6^{th} Edition,2001
2	Chemical Engineering: Particle technology and Separation processes	Coulson J. M and J. F Richardson	Butterworth-Heinemann	Vol - II, 5^{th} Edition, 1999

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Chemical Engineering: Fluid flow, Heat transfer and Mass transfer	Coulson J. M and J. F Richardson	Butterworth-Heinemann	V*ol - II,* 5^{th} Edition, 1999
2	Introduction to Particle Technology	Martin J. Rhodes	John Wiley & Sons	2^{nd} Edition, 2008
3	Perry's Chemical Engineer's Handbook	Perry R. H. and D.W. Green	McGraw Hill	7^{th} Edition, , 1997
4	Mechanical Operations For Chemical Engineers: Incorporating Computer Aided Analysis	Narayanan C.M. & Bhattacharya B.C	Khanna Publishers	

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (7 Marks)**

   - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
   - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. **Conduct of Experiments (7 Marks)**

   - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
   - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
   - Teamwork: Collaboration and participation in group experiments.

3. **Lab Reports and Record Keeping (6 Marks)**

   - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
   - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**
   - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 5

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

Common for

BIOTECHNOLOGY ENGINEERING

SEMESTER S5

HEAT TRANSFER OPERATIONS

Course Code	**PCBBT501**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. The course offers a prefatory on the third major class of unit operations involved in process engineering, namely heat transfer. The fundamental theory and applications of heat transfer shall be explicated, with adequate emphasis on relevant case studies and numerical exercises.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Conduction Heat Transfer:** General heat conduction equation in rectangular geometry, Laplace equation, Poisson equation, heat diffusion equation, different boundary conditions applied in heat transfer problems, Fourier's law, thermal conductivity of materials, Steady state unidirectional heat flow through single and multiple layer slabs, cylinders and spheres with constant and variable thermal conductivities. Numerical problems. Solution of steady-state one-dimensional heat conduction with heat generation in slabs, cylinders, and spheres. Numerical problems. **Unsteady state conduction**: Elementary treatment of unsteady state heat conduction Lumped capacity analysis. Biot Modulus, Fourier number, and their significance. Numerical problems. Chilling and freezing of food and biological materials. Unsteady state thermal processing and sterilization of biological materials.	9

2	**Convection Heat Transfer:** Forced and natural convection – Dimensional analysis Dimensional numbers, Convection heat transfer coefficient, Correlations for flow over the plate, through tubes, over spheres and cylinders, Film concept of heat transfer, Individual and overall heat transfer coefficient, LMTD, LMTD correction factor. **Insulation and Extended Surfaces:** Properties insulation materials, Types of insulation, Critical and Optimum thickness of insulation. An overview of Fins and their different variants (detailed heat transfer analysis is not desired).	**9**
3	**Radiation Heat Transfer And Heat Transfer Equipment:** Properties and definitions, Absorptivity, Reflectivity, Emissiv power and intensity of radiation, Black body radiation, Gray body radiation, Stefan – Boltzmann law, Wien's displacement law, Kirchoff law **Heat transfer equipment**: Detailed classification of heat exchangers based on different modes, Types of shell and tube heat exchangers, and their constructional details indicating the function of various components. Elementary design as to the determination of area, length, and number of tubes for shell and tube heat exchanger and condensers -Numerical problems. **Evaporators**: Types of evaporators, performance of tubular evaporator – Evaporator capacity, Evaporator economy, Material and energy balance in single effect evaporators. Multiple-effect evaporators – Methods of feeding and calculations on single-effect evaporators alone are desired. - Numerical problems.	**9**
4	**Heat Transfer With Phase Change:** **Boiling heat transfer**: Types of boiling, factors affecting boiling heat transfer coefficient, dimensionless variables, Pool boiling curve, Correlations for determining boiling heat transfer coefficient- Rohsenow correlation, Critical heat flux- Zuber correlation and minimum heat flux- numerical problems. Elementary treatment of flow boiling with its different regimes **Condensation** – Types of condensation, Nusselt's equation (Derivation is required), correlations for determination of condensing coefficients for film condensation on single cylinders (horizontal and vertical orientations), spheres banks of tubes- Numerical problems	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination-2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundaments of three modes of heat transfer	**K1**
CO2	Apply knowledge on the steady, unsteady, and combined resistances of conduction and convection	**K2**
CO3	Analyze the design of various industrial heat exchangers and evaporators for higher education in the field of Biotechnology.	**K3**
CO4	Analyze boiling and condensation process of heat transfer	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1			1						1
CO2	3	3	2			1						1
CO3	3	3	2			1						1
CO4	3	3	2			1						1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Heat Transfer- Principles and Applications	Dutta B. K	Prentice Hall of India	2000
2	Heat Transfer,	Holman J. P	McGraw Hill,	1992
3	Process Heat Transfer,	Kern D. Q.,	McGraw Hill,	1997
4	Heat and Mass Transfer Data Book,	Kothandaraman C. P. and S. Subramanyan,	New Age International	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Heat Exchanger Design,	Shah K. and D. P.Sekulic,	.John Wiley	2003
2	Heat Transfer - A Basic Approach,	Ozizik M. N	McGraw Hill	1985
3	Introduction to Heat Transfer,	Incropera F. P. and D. P. DeWitt,	2/e, John Wiley,	1996

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Heat Transfer - Course (nptel.ac.in)
2	NPTEL :: Chemical Engineering - NOC: Heat Transfer
3	Heat Transfer - Course (nptel.ac.in)
4	NPTEL :: Mechanical Engineering - NOC: Conduction and Convection Heat Transfer

SEMESTER S5

BIOPROCESS ENGINEERING

Course Code	**PCBBT502**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

Course Objectives:

The student should be made to,

1. Provide the students with the basics of bioreactor engineering.
2. Develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of bioprocess engineering:** Engineering perspective of fermentation processes, integrated bioprocessing- comparison of bioprocess engineering with biochemical engineering. **Kinetics of microbial growth and product formation:** - Batch growth curve- kinetics of exponential growth- implications of endogeneous and maintenance metabolism- death phase kinetics- yield and maintenance coefficients- classification of microbial products - growth associated, non-growth associated and mixed growth associated product formation-Leudeking Piret equation-influence of various environmental conditions such as temperature, pH, DO concentration, redox potential, DCO_2 concentration, ionic strength and substrate concentration on growth kinetics **Thermal death kinetics of cells and spores:** Survival curve- decimal	11

	reduction factor, Extinction probability-sterilization of culture medium-batch and continuous sterilization- design aspects- air sterilization- design of fibrous type filters.	
2	**Medium engineering for cell cultivation and bioreaction:** Technological concerns of medium design engineering in bioprocessing-design procedure for growth and production medium- stoichiometric design approach-bioorganic reaction medium engineering- Novel media. **Kinetic modelling of cell growth:** Model structure and complexity-different perspectives for kinetic representations sing models- prediction of specific growth rate using unstructured un-segregated models-Monod equation- Monod chemostat model- Models with growth inhibitors (substrate inhibition, product inhibition and inhibition by toxic compounds)-logistic equation- growth models for filamentous organisms-structured kinetic models- compartment models, metabolic models, cybernetic models. **Mass transfer in bioprocessing systems:** Gas liquid mass transfer-volumetric oxygen transfer coefficient, correlations (Cooper correlation, Richards correlation) – oxygen transfer mechanism- assessment of KLa-chemical method, dynamic differential gassing out method, dynamic integral gassing out method, oxygen balance method, enzymatic method-merits and demerits of each method. **Scale up and scale down of bioprocess systems**: Need for scale up and scale down- operating boundaries for aerated and agitated fermenters- scale up criteria for microbial cell processes- constant power input per unit volume, constant KLa, constant mixing quality constant impeller tip speed,	**11**
3	**Monitoring and Control of Bioprocesses:** Fermentation monitoring: Various physical, chemical and biological parameters measured or controlled in bioreactors-Physical and chemical sensors for fermentation medium and gases- online sensors for cell properties-offline analytical methods **Process control:** Open loop and closed loop control-direct regulatory control, cascade control of metabolism-programmed control- application of artificial intelligence in bioprocess control-knowledge based expert systems, neural networks (A brief overview of the above is only required).	**11**

	Bioprocess modeling and simulation: Structure of bioprocess models-concept of balance domain- model validation using MATLAB- objectives and benefits of bioprocess simulation-simulation tools such as SIMULINK, Biopro Designer, Biotechnology Design Simulator and Bioprocess Simulator.	
4	**Immobilized cell systems:** Potential advantages of cell immobilization, methods of active and passive immobilization-diffusional limitations in immobilized enzyme systems-bioreactor considerations. **Bioprocess considerations in using plant and animal cell cultures:** Methods for cultivation of animal cells-requirements for culturing of animal cells-bioreactor design considerations- perfusion systems-products of animal cell cultures- -bioreactor considerations for suspension cultures, immobilized systems and organ cultures- products of plant cell cultures. **Medical applications of bioprocess engineering:** overview of tissue engineering-commercial tissue culture processes gene therapy using viral vectors-use of bioreactors as artificial hybrid organs and for mass production of cells for transplantation.	11

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Design a fermentation process in a bioreactor	**K5**
CO2	Analyze the cell growth and product formation in different cultivation systems	**K4**
CO3	Design batch and continuous sterilization	**K5**
CO4	Perform modeling and simulation of bioprocess	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	3	2		1	2				2
CO2	3	3	2	2	2	1	1					2
CO3	3	3	2	2			1					2
CO4	3	3	2	2	1	1	2	2				2
CO5	3	3	2	3	2		1	2				2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioprocess Engineering Principles	Pauline M Doran	Elsevier- Academic Press	Second, 2013
2	Biochemical Engineering Fundamentals	James. E.Bailey, David.F. Ollis	2nd Edition, McGraw Hill	2017
3	Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design	Shijie Liu	Elsevier	2020

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioprocess Technology:Kinetics and Reactors	Anton Moser,	Springer Verlag	2012
2	Principles of Fermentation Technology	P. F. Stanbury, S. J. Hall and A. Whitaker	, 3 rd Edition, Elsevier	2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/102/105/102105064/ https://nlinecourses.nptel.ac.in/noc22_bt19/preview

SEMESTER S5

MASS TRANSFER OPERATIONS

Course Code	PCBBT503	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. Provide an insight into the fundamental concepts of mass transfer with the understanding of the relevant separation processes employed in the bio-processing industry.
2. Offer a prefatory on the design of purification strategy based on product characteristics and cost effectiveness.
3. Predict optimal operating parameters for large scale operations.
4. Explicate the techniques of bulk product isolation and purification

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Mass transfer operations**: Classification, Fick's law of diffusion, diffusivity measurement, Steady state molecular diffusion, One component transferring to non-diffusing component and equimolar counter diffusion (Numerical problems), Theories of mass transfer: Film theory, Penetration theory, and Surface Renewal theory. Convective mass transfer, Mass transfer coefficients. Interphase mass transfer, Dimensionless numbers, Equipment for gas-liquid operations- Tray tower and packed tower. Broad classification of bioproducts, Criteria for choice of recovery products, Problems and requirements of bioproduct purification.	9
2	**Distillation**: Principle, Vapour- Liquid Equilibrium, Raoult's law, Dalton's law, Relative volatility, Azeotropes, Flash vaporization, Simple distillation,	9

	Rayleigh's equation (Numerical problems), Steam distillation- Applications, General characteristics of tray and packed towers. Continuous fractionation, Material and energy balance in a continuous fractionator, McCabe-Thiele method to find the number of theoretical plates (Numerical problems), total reflux ratio, minimum reflux ratio, optimum reflux ratio, total condenser and partial condenser, reboiler.	
3	**Liquid-liquid Extraction**: principle, Industrial applications, Selection of a solvent for good extraction, Type 1 liquid extraction, Single stage, cross current and counter current extraction, Liquid-liquid extraction equipments-centrifugal extractors, reciprocating plate column extractors, Reversed micellar extraction and super critical fluid extraction- principles and process. **Solid-Liquid extraction (Leaching)**: Industrial applications, Heap and In-situ Leaching, Single stage and multistage leaching, Leaching equipment, solid-liquid equilibria. **Adsorption**: Adsorbent types, Adsorption equilibrium- Freundlich equation, equipment operation- adsorption column dynamics- fixed bed and agitated bed adsorption, adsorption wave - break through curves and rates of adsorption. scale up of adsorption processes LUB method.	**9**
4	**Drying**: Principle, Heat and mass transfer in drying applications, Commercial dryers- vacuum dryers, fluidized bed dryers, freeze dryers and spray dryers, Different regimes of drying in standard rate of drying curve Material and energy balance in a continuous counter current dryer, Drying time determination (Numerical problems). **Membrane separation processes**: Ultra filtration, micro filtration, reverse osmosis- concentration polarization and fouling, dialysis, electrodialysis, pervaporation, perstraction. **Ion exchange**: Principles of ion exchange techniques and application - Ion exchange Equilibira - Rate of ion exchange. **Chromatography**: Classification of techniques- principle and process, Types- Elution, gas-liquid, bonded phase, gel-permeation and supercritical fluid chromatography.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify the mechanism of mass transfer, formulate rate equations and evaluate industrial problems	**K5**
CO2	Analyse the problems associated with distillation columns.	**K4**
CO3	Design calculations for extraction, leaching and adsorption.	**K5**
CO4	Summarize the theoretical principles underlying various unit operations used in downstream processing.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2							2		2
CO2	3	2	2							2		2
CO3	3	2	2							2		2
CO4	3	2	2							2		2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mass Transfer Operations	Robert E Treybal	Mc Graw Hill	^{d}Edition,1980
2	Mass Transfer Operations : Theory and Applications	K V Narayanan & B Lakshmikutty	CBS Publishers	2ndEdition, 2023
3	Transport Processes and Separation Process Principles	Geankoplis, C.J	Pearson	5th Edition, 2015.
4	Mass Transfer : Theory and Practice	N Anantharaman , K M Meera Sheriffa Begum	Prentice Hall of India	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Mass Transfer and separation Processes	Binay K Dutta	Prentice Hall of India	2009
2	Bioseparations: Principles and Techniques	Sivasankar B	Prentice Hall of India	2008
3	Unit Operations of chemical Engineering	Warren L McCabe, Julian C Smith, P Harriot	McGraw Hill	7th Edition, , 2005
4	Bioseparations: Downstream Processing for Biotechnology	Paul A Belter, E L Cussler, Wei-shou Hu	Wiley Interscience	1988

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://www.nptelvideos.com/course.php?id=169
2	https://www.nptelvideos.com/course.php?id=169
3	https://archive.nptel.ac.in/courses/103/103/103103154/
4	https://archive.nptel.ac.in/courses/103/103/103103154/

SEMESTER S5

ENZYME KINETICS & TECHNOLOGY

Course Code	PBBBT504	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Basic understanding of biochemistry	Course Type	Theory

Course Objectives:

1. This course makes the students aware of the overall industrial bioprocess to help them manipulate the process to the requirement of the industrial needs.
2. This course prepares the students for the bulk production of commercially important Industrial Enzymes for industrial applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Methods of Enzyme extraction**. Study the basic structure nomenclature and classification, of the enzyme, Study the conformation and stereochemistry of the extracted enzyme. The influence of enzyme conformation and stereochemistry on its activity and specificity in biological reactions, Study the shape of an enzyme's active. Alterations in an enzyme's shape	9
2	**Production of Extracted Enzyme:** Design a bioreactor system that provides optimal conditions for enzyme production. **Purification of the extracted enzyme:** Purify the enzyme from a suitable source and other impurities. **Common purification techniques: C**entrifugation, Filtration, Precipitation techniques such as salting out or organic solvent precipitation; Membrane separation; Dialysis; Gel filtration chromatography; Affinity chromatography, and Crystallization	9

3	**Enzyme Characterization Approaches:** 1. Determination of enzyme activity: 2. Determination of enzyme kinetics: Determine parameters such as Km (substrate affinity) and Vmax (maximum reaction rate). 3. Temperature and pH profiles: Determining the optimal temperature and pH conditions for enzyme activity. 4. Stability studies: assessing the enzyme's stability under different storage conditions. 5. Substrate specificity studies: Investigate the enzyme's ability to recognize and bind different substrates. 6. Inhibitor studies: testing the effect of various inhibitors on enzyme activity to understand the mechanism of inhibition. 7. Molecular and structural analysis: techniques such as nuclear magnetic resonance (NMR) spectroscopy, or mass spectrometry.	**9**
4	**Bioengineer and immobilize the extracted enzyme:** Application and Case study on the purified enzyme in any one of the applied fields such as the medical field in the environmental field, drug discovery, or the textile industry field	**9**

Suggestion on Project Topics

Project-Based Learning: Extraction Characterization and Purification of Enzyme from a suitable source carrying out scheme

1. In the first class before starting the first module, direct the students to select an enzyme that can be selected from a suitable plant, animal, or microbial source and do an adequate literature review before the start of the project. Students should study the basic structure, including its nomenclature and classification of the extracted enzyme. The focus will be on investigating the conformation and stereochemistry of the extracted enzyme and understanding how these factors influence the enzyme's activity and specificity in biological reactions. The project will also involve studying the shape of the enzyme's active site and exploring any alterations that may occur in the enzyme's shape.

2. Once the enzyme is extracted, students will work on designing a bioreactor system that provides optimal conditions for enzyme production on a larger scale. This will enable the enzyme to be produced in bulk quantities. The enzyme can then be purified using various purification strategies.

3. Various characteristics of the extracted enzyme, such as stability, pH and temperature optima, and substrate specificity, will be studied. Students will also explore the potential applications of the enzyme in one of the applied fields, such as textile, food, environmental, pharmaceutical, or medical industries. The application will be justified through experimentation, demonstrating the enzyme's effectiveness in a specific industry or process.

4. Overall, this project will provide students with a comprehensive understanding of enzymes, their structure, and their potential applications in various industries. It will also provide hands-on experience in enzyme extraction, production, and purification techniques. Project-based learning is considered successful only after the completion of the project and submission of the report to the faculty

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 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 sub divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply the rules of enzyme classification and principles of enzyme catalysis in metabolic reactions.	**K3**
CO2	Analyse and investigate the enzyme kinetics and give appropriate interpretations of the kinetic parameters of free and immobilized enzymes.	**K4**
CO3	Investigate the enzyme inhibition kinetics and apply modern computational tools for the interpretation of kinetic data.	**K5**
CO4	Design a bioreactor to enhance the production of enzymes	**K6**
CO5	Propose strategies for quantifying enzyme activity and improving catalytic efficiency in the context of industrial applications	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2		2		1	2	2		2
CO2	3	3	2	2		2		1	2	2		2
CO3	3	3	2	2	2	2		1	2	2		2
CO4	3	3	3	2	2	2		1	2	2	2	2
CO5	3	3	2	2	2	2	2	2	2	2	2	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fundamentals of Enzyme Kinetics	Athel Cornish-Bowden	Elsevier	2019
2	Enzyme Kinetics: Principles and Methods, 3rd, Enlarged and Improved Edition	Hans Bisswanger	Wiley Online Library	2017
3	Enzyme Kinetics and Mechanism	Paul F Cook, W W Cleland	CRC Press Book	2020

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Enzymes: biochemistry, biotechnology, clinical chemistry.	Palmer, T., & Bonner, P.L	Elsevier, 2007	2007
2	Understanding Enzymes: Function, Design, Engineering, and Analysis.	Svendsen, A. (Ed.).	CRC Press. 2016	2016
3	Enzymes: catalysis, kinetics and mechanisms.	Punekar, N. S.	Springer. 2018	2018
4	How enzymes work: from structure to function.	Suzuki, H.	CRC Press. 2019	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	Enzyme Sciences and Technology - Course (nptel.ac.in)
2	
3	
4	

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**

- Active participation and individual contribution
- Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

5. **Final Presentation (5 Marks)**

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches

SEMESTER S5

CANCER BIOLOGY

Course Code	**PEBBT521**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge of Biochemistry, Cell Biology and Molecular Biology	**Course Type**	Theory

Course Objectives:

The goal of this course is to enable the students to

1. Understand the basics of cancer and cancerous cells
2. Discuss the significance of carcinogenesis in the development of cancer
3. Interpret the role of oncogenes and their growth factors
4. Make an understanding of the process of cancer metastasis and its dysregulation factors
5. Gain knowledge on the advancement in cancer treatment
6. Design novel drugs to treat cancer or to reduce the effect of carcinogenesis

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Fundamentals of cancer biology -** Role of biomolecules in cancer – Carbohydrates, Proteins and Lipids, Membrane components. Role of Biomolecules Membrane trafficking, The Proteasome, and Cancer. Principles of Carcinogens - Theory of carcinogenesis, Chemical carcinogenesis, Physical Carcinogens, metabolism of carcinogenesis, principles of physical carcinogenesis, x-ray radiation mechanisms of radiation carcinogenesis	**9**

2	Definition of cancer, different forms of cancers, different causes of cancer - mutations and cancer. Lifestyle and environment (diet and other lifestyle factors) age, histopathology of cancer, hallmarks of cancer. Cancer cell growth and spreading of cancer. Cell Signalling - Effects of receptors in cell signaling, signal switches G-protein coupled receptors, **G protein, Ras and rho family signaling** –Types of Cell signaling, Hedgehog signaling	**9**
3	Metastasis and the Cytoskeleton **-** Overview of the Cell Cycle, Regulation of cell cycle, Modulation of cell cycle in cancer. DNA damage and checkpoint, Cytoskeletal regulatory proteins. Overview of the ECM, Regulators of the tumor microenvironment, Extracellular matrix alterations in the tumor microenvironment, and extracellular matrix fragments as tumor biomarkers. Cellular motility and metastasis. p53 and Apoptosis. Signaling Receptor tyrosine kinases Oncogenes -Tumour suppressor genes.	**9**
4	Therapy - Importance of early detection of cancer. Molecular tools used for the diagnosis of cancer. Methods of prevention of cancer. Treatment of cancer - Different forms of therapy, chemotherapy, radiation therapy, prediction of aggressiveness of cancer, Use of signal targets towards therapy of cancer. Gene Therapy, Role of virus in cancer therapy, Importance of advanced technology in cancer therapy	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the hallmarks of cancer and cancer cell characteristics	**K2**
CO2	Analyze the mechanisms of protooncogene-oncogene conversion and its role in cancer development	**K4**
CO3	Apply the concepts of cell cycle regulation and illustrate how cell cycle dysfunction can lead to cancer	**K3**
CO4	Understand chemical, radiation-induced carcinogenesis, and hormone-dependent cancers	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										3
CO2	3	3	2									2
CO3	3	3	2									2
CO4	3	3										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Biochemistry	David L Nelson Michael M Cox	Lehninger	8^{th} edition 2021
2	Enzymes: Biochemistry, Biotechnology, Clinical Chemistry.	Palmer, Trevor.	East West Press	2nd Edition, 2008
3	The Biology of Cancer	Weinberg, R. A	Garland Science	2007
4	Molecular Biology of Cancer”	McDonald, F et al	Taylor & Francis	II^{nd} Edition 2004

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Biochemistry 4th Edition	Voet & Voet	Publisher Wiley	2013
2	“Enzyme Technologies: Metagenomics, Biocatalysis and Biosynthesis”	Yeh W.K., Yang H.C., James R.M	Wiley Blackwell,	2010
3	Cancer Biology” III^{rd} Edition	King, Roger J.B	Wesley Longman	1996
4	The Science of Cancer Scientific American	Suzie Althens	Blackstone Publishers	2020

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.swayam2.ac.in/aic20_ge02/preview https://onlinecourses.nptel.ac.in/noc21_cy15/preview
2	
3	
4	

SEMESTER S5

BIOETHICS AND SAFETY

Course Code	**PEBBT522**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs.30 Min.
Prerequisites (if any)	NIL	**Course Type**	Theory

Course Objectives:

1. This course aims to equip students with a deep understanding of the ethical and safety considerations involved in biotechnology, biomedical research, and related fields

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Responsible Conduct of Science:** Values in science, responsible conduct of science, scientific publications, misconduct in science, negligence, and error, conflict of interest, academic honesty, research fabrication and falsification, plagiarism, plagiarism policies, consequences, detection tools, Image manipulation, ethical violations, reference management, research with humans, animals and stem cells-Intellectual property rights, patenting, patent laws, authorship, and author disputes	9
2	**Laboratory Safety:** Biohazards, risks and safety equipment, biosafety cabinets, biosafety levels 1 and 2, 3 and 4, containment laboratory, good microbiological techniques, Recombinant DNA technology, and biosafety, handling hazardous chemicals, electrical and fire accidents, laboratory decontamination, chemical disinfection, gaseous disinfection, heat sterilization, biological indicators, chemical transport, storage and usage, radiation safety, electrical safety, fire safety, biohazard spills, and bio-waste segregation	9

3	**Guidelines for research in stem cells, hazardous microorganisms, and genetic modifications:** Recombinant DNA technology work, genetically engineered organisms, and non-GE hazardous microorganisms, biosafety and biosecurity at the institute, National guidelines for stem cell research, Institutional biosafety committee compliance adherence, containment and storage of hazardous microorganisms and genetically modified organisms Decontamination and disposal	9
4	**Ethics in animal and human research:** Ethical guidelines for the use of animals in research, Committee for Control and Supervision of Experiments on Animals (CCSEA), guidelines, the role of the institutional animal ethics committee, guidelines for the use of rodents, fishes, birds, and large animals, Ethical guidelines for biomedical research in human participants, Indian Council of Medical Research (ICMR) guidelines, Institutional human ethics committee roles, and responsibilities, International guidelines for recombinant DNA technology work	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the ethical values in scientific research and ethical violations	**K2**
CO2	Analyze the biological, chemical, physical, and radioactive laboratory hazards and their prevention and safety measures	**K4**
CO3	Apply the concepts and ethical guidelines to carry out research in genetic engineering, animal, human, and stem cell research	**K3**
CO4	Summarize the national and international guidelines and policies for good laboratory practices and biosafety	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3						2				**2**
CO2	3	3						2				2
CO3	3	3				2		2				2
CO4	3	3				2		2				2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook for Institutional Biosafety Committee		Department of Biotechnology, Govt of India.	2017 & 2020
2	Laboratory Biosafety Manual 4th edition and associated monographs- Decontamination and Waste Management		World Health Organization	2020.
3	National guidelines for stem cell research		Department of Biotechnology and Indian Council of Medical Research, 2017	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	National ethical guidelines for biomedical and health research involving human participants –		Indian Council of Medical Research-2017	2017
2	An Introduction to Ethical, Safety, and Intellectual Property Rights Issues in		Biotechnology Padma Nambisan eBook ISBN: 9780128092514 Elsevier 2017	2017
3	Ethics in research- Editors https://doi.org/10.1007/978-3-031-24060-7	Lorella Congiunti, Francesco Lo Piccolo, Antonio Russo, Mario Serio	Springer 2023	2023

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/109106092
2	https://archive.nptel.ac.in/courses/109/106/109106092/
3	https://onlinecourses.nptel.ac.in/noc24_bt77/preview

SEMESTER S5

BIOPHYSICS

Course Code	PEBBT523	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Understanding of Thermodynamics and Cell biology	Course Type	Theory

Course Objectives:

1. This course aims to prepare the students to understand the Molecular Structure & Interactions of Biological Systems and Energetics and Dynamics of Biological Systems and physical principles of living systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Molecular Structure & Interactions of Biological Systems:** Molecular and Ionic intermolecular interactions as the basis for biological structure formation: Hydration radii, Debye-Huckel Radii, Intermolecular interactions	9
2	**Biomolecular interfaces Interfacial phenomena and Membranes:** Surface tension, Phase boundaries, Adsorption Isotherms, Self-assembly, van der Waals theory, Electrical Double layers, DLVO theory;	9
3	**Energetics and Dynamics of Biological Systems:** Fundamentals of Thermodynamics & Equilibrium: Free Energy, Entropy, Van't Hoff Equation; Diffusion dynamics and kinetics: Flux, Brownian Diffusion, Stokes-Einstein Equation; Mechanical Properties of Biological materials: viscosity, Visco-elastic properties; Crowded and Disordered dynamics;	9

4	**Physical principles in Living Systems:** Dynamics of Molecular Motors; Mitochondrial Fission & Fusion dynamics; Membrane Lipid Diffusion Dynamics; Protein Folding Kinetics	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the basic principles of physical interaction to biological systems	**K3**
CO2	Analyze the theories that formulate the biomolecular interfaces	**K4**
CO3	Apply the fundamentals of bioenergetics and diffusion dynamics to interpret the properties of biological materials	**K3**
CO4	Illustrate the physical functioning principles of membrane organelles and molecules in living systems.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		2	2							**2**
CO2	3	2										2
CO3	3	2					2					2
CO4	3	2										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biophysics: an introduction.	Glaser, R.	Springer Science & Business Media. 2012	2012
2	Physical biology of the cell.	Phillips, R., Kondev, J., Theriot, J., & Garcia, H.	Garland Science. 2012	2012
3	Biophysics: An Introduction.	Cotterill, R.	John Wiley & Sons. 2003	2003

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biophysics: a physiological approach.	Dillon, P. F.	Cambridge University Press. 2012	2012
2	Fundamentals of Biophysics.	Rubin, A. B.	John Wiley & Sons. 2014	2014
3	Biological Thermodynamics.	Haynie, D. T.	Cambridge University Press. 2008	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_ph13/preview
2	https://archive.nptel.ac.in/courses/104/102/104102009/
3	https://onlinecourses.nptel.ac.in/noc22_bt32/preview
4	https://archive.nptel.ac.in/courses/115/101/115101121/

SEMESTER S5

GENETIC ENGINEERING

Course Code	PEBBT524	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge of Molecular Biology	Course Type	Theory

Course Objectives:

This course will enable students to

1. To provide an advanced introduction to the field of genetic engineering, which constitutes the most popular realm of Biotechnological application.
2. To describe the gene cloning tools and techniques and the heterologous expression of cloned genes in different hosts, production of recombinant proteins and PCR techniques.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Basics Of Recombinant DNA Technology:** Manipulation of DNA – Restriction and Modification enzymes, Design of linkers and adaptors. Characteristics of cloning and expression vectors based on plasmid and bacteriophage, Vectors for insect, yeast and mammalian system, P (Plasmids, Bacteriophages, M13 mp vectors, PUC19 and Bluescript vectors, Phagemids, Lambda vectors: Insertion and Replacement vectors, pEMBL, Cosmids) Introduction of recombinant DNA in to host cells and selection methods	9

2	**DNA Libraries:** Construction of genomic and cDNA libraries, Artificial chromosomes – BACs and YACs, Chromosomal walking, Screening of DNA libraries using nucleic acid probes and antisera. **Sequencing And Amplification Of DNA:** Maxam Gilbert's and Sanger's methods of DNA sequencing. Inverse PCR, Nested PCR, AFLPPCR, Allele specific PCR, Assembly PCR, Asymmetric PCR, Hot start PCR, inverse PCR, Colony PCR, single cell PCR, Real-time PCR/qPCR – SYBR green assay, Taqman assay, Molecular beacons. Site directed mutagenesis.	9
3	**Organization And Structure Of Genomes:** Organization and structure of genomes, Genome sequencing methods, Conventional and shotgun genome sequencing methods, Next generation sequencing technologies, Ordering the genome sequence, Genetic maps and Physical maps, STS content based mapping, Restriction Enzyme Finger Printing, Hybridization mapping, Radiation Hybrid Maps, Optical mapping. ORF finding and functional annotation.	9
4	**Gene silencing techniques:** Introduction to siRNA, siRNA technology, Micro RNA, Construction of siRNA vectors, Principle and application of gene silencing. Methods of gene transfer: Gene transfer in Animals, Agrobacterium mediated gene transfer and biolistic. Gene knockouts: Creation of knockout mice, Disease model **Gene Therapy**: Somatic and germ-line therapy- in vivo and exvivo, Gene replacement, Gene targeting Production of recombinant proteins: Production of insulin, growth hormones and monoclonal antibodies	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand To be aware of gene and genome sequencing techniques	**K2**
CO2	Design modern tools and techniques for manipulation and analysis of genomic sequences	**K5**
CO3	Develop skills in microarrays, analysis of gene expression and proteomics	**K5**
CO4	Strategize research methodologies employing genetic engineering techniques	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3					2					2
CO2	3	3	2				2					3
CO3	3	3	2	2			2					3
CO4	3	3	2				2					2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Old RW, Primrose SB, “Principles Of Gene Manipulation, An Introduction To Genetic Engineering “, Blackwell Science Publications, 1993.	Metcalf & Eddy	4th edition. Tata McGraw-Hill	2003
2	Principles of Genome Analysis and Genomics by S.B.Primrose and R.M.Twyman, 3rd Ed Wiley-Blackwell 2002	Mark.J.Hammer&Mark.J. Hammer J	Prentice Hall of India. Ltd.	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Ansubel FM, Brent R, Kingston RE, Moore DD, “Current Protocols In Molecular Biology“Greene Publishing Associates, NY, 1988.	Peavy, Rowe &Tchobanoglous	MCGraw-Hill	2015
2	Berger Sl, Kimmer AR, “Methods In Enzymology”, Vol 152, Academic Press	Casey, T.J.,	Wiley Interscience	1997
3	Membrane Separation Processes	Kaushik Nath	PHI	2016

SEMESTER S5

BIOLOGICAL WASTEWATER TREATMENT

Course Code	**PEBBT526**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

This course will enable students to

1. Gain knowledge of advanced wastewater technologies
2. Understand the design and operation of the wastewater treatment process
3. Study on Electrochemical wastewater treatment processes and advanced oxidation processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of Advanced Waste Water Treatment:** Need of Advanced wastewater treatment, Technologies used for Advanced waste water treatment-Classification of Technologies. Nutrient Removal –Nitrogen Removal: Nitrification, Denitrification, Simultaneous nitrification and denitrification. Phosphorus Removal: Introduction, Phosphorus removal by Chemical Precipitation: Principles of process, Chemicals applied, Chemistry of phosphorus precipitation, Process configuration, Phosphorus removal by Biological Precipitation: Principles of the process, Microorganisms involved in the process, Process configurations.	**9**
2	**Wastewater Treatment: Primary treatmen**t: Screening, Grit removal, Neutralization, equalization, Sedimentation, Flotation (oil & grease removal), Air stripping. **Secondary treatment:** principles of waste treatment, basic kinetic equation, continuous flow treatment models, oxygen	**9**

	requirement in aerobic process, production of sludge. Conventional biological process: Activated Sludge Process (ASP)- development of material balance equations, Trickling Filters, UASB and RBC anaerobic filters. Low-cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches.	
3	**Advanced Treatment Options: Tertiary treatment** – ion exchange, Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes. Adsorption: Introduction, Fundamentals of adsorption, Type of adsorbents, Activated carbon adsorption, Granular carbon adsorption.	**9**
4	**Electrochemical Wastewater Treatment Processes:** Introduction, Electro-coagulation: Factors affecting Electrocoagulation, Electrode materials, Reactor configurations. Electro-floatation: Factors affecting electro floatation, Comparison with other technology, Reactor configurations, Electro-oxidation: Electro oxidation process, Reactor configurations. Advanced Oxidation Processes: Theory of advanced oxidation, Types of oxidizing agents, ozone based and non- ozone based processes, Fenton and photo-Fenton Oxidation. Solar Photo Catalytic Treatment Systems.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the concepts of advanced technologies in Wastewater treatment	**K3**
CO2	Analyse primary and secondary treatment methods	**K4**
CO3	Select the most appropriate processes for the tertiary treatment of wastewater	**K3**
CO4	Explain different types of electrochemical treatment options for wastewater treatment	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3					2					2
CO2	3	3					2					3
CO3	3	2					2					3
CO4	3	2					2					

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Wastewater Engineering – Treatment and Reuse	Metcalf & Eddy	4th edition. Tata McGraw-Hill	2003
2	Water and Wastewater Technology	Mark.J.Hammer&Mark.J. Hammer J	Prentice Hall of India. Ltd.	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Engineering	Peavy, Rowe &Tchobanoglous	MCGraw-Hill	2015
2	Unit Processes in Water and Wastewater Engineering	Casey, T.J.,	Wiley Interscience	1997
3	Membrane Separation Processes	Kaushik Nath	PHI	2016

SEMESTER S5

BIOSEPARATION TECHNOLOGY

Course Code	PEBBT525	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	5/3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Basic knowledge of Biochemistry, Cell Biology and Molecular Biology	Course Type	Theory

Course Objectives:

1. To acquire an insight into the principles of various unit operations employed in the recovery, Purification, and formulation of bioproducts.
2. To understand the heuristics and structure of bioseparations to facilitate process scheduling and economic evaluation.
3. To illustrate the modular and integrated approach for industrial bioseparations in the backdrop of relevant examples and case studies

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of bioseparations**: Classification of bioproducts, range, and characteristics of bioproducts, need for downstream processing in bioprocess industries, synthesis of bioseparation processes-heuristics and structure of recovery and purification processes, separation factors and unit operations in bioseparations, criteria for choice of recovery processes. **Cell disruption and intracellular product release:** Categories of cell disruption methods- physicomechanical methods, chemical and biological methods. **Cell aggregation and flocculation**: Principles and mechanisms underlying cell flocculation, polymeric flocculants.	9

	Adsorptive bubble separations: Classification of techniques, foam fractionation-principle, and applications.	
2	**Gravity settling:** Sedimentation of fine particles, industrial sedimentation equipment- classifiers, clarifiers, and thickeners. **Centrifugal bioseparations:** Principles of centrifugal settling, range of centrifuges- tubular bowl, basket, scroll centrifuge, multi-chamber, and disc stack centrifuges. **Filtration:** General filtration theory, use of filter aids, filter media, and filtration equipment-batch and continuous filters. **Membrane separation processes**: Principles of cross-flow filtration, classification of membrane filtration operations, membrane properties, membrane filtration equipment- membrane modules, process configurations, and modes of operation.	**9**
3	**Precipitation**: Factors affecting protein solubility, classification of protein precipitation methods, large-scale protein precipitation, precipitation reactors. **Extractive bioseparations**: Solvent extraction principles, physical, dissociative, and selective extraction, equipment for solvent extraction, operating modes of extraction- batch and continuous, single and multi-stage operations, fractional and differential extraction aqueous two-phase extraction, reverse micellar extraction and supercritical fluid extraction, solid-liquid extraction in bioprocessing. **Evaporation**: Heat transfer principles, evaporation equipment-climbing-film, falling-film, forced-circulation and agitated-film evaporators. **Adsorptive bioseparations**: Adsorption isotherms, adsorption techniques, and continuous. **Chromatographic separations**: Classification of chromatographic techniques, general description of column chromatography, practice of chromatography, process considerations.	**9**
4	**Crystallization**: Crystallization principles- nucleation and crystal growth, batch crystallizers, process crystallization of proteins, recrystallization. **Drying:** Water in biological solids and gases, dryer description and operation-Vacuum-shelf dryers, batch vacuum rotary dryers, spray dryers, and freeze dryers.	**9**

	Bioprocess integration and intensification: *in-situ* product recovery and whole broth processing, principles and advantages of process intensification **Economics of industrial bioseparations:** Capital cost and operating cost estimation, profitability analysis. **Case studies in bioseparations**: Citric acid, Insulin and therapeutic monoclonal antibody production- process scheduling and economic evaluation.	

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Outline the principles of various unit operations employed in the recovery, purification, and formulation of bioproducts.	**K2**
CO2	Explain the heuristics and structure of product recovery and purification processes.	**K2**
CO3	Demonstrate the scheduling and economic evaluation of product recovery stages in an industrial bioprocess.	**K3**
CO4	Compare the modular and integrated approaches in downstream processing for recovery and purification of various bioproducts.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										2
CO2	2	2										2
CO3	3	3									3	2
CO4	2	2										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioseparations Science and Engineering	Roger G Harrison, Paul W Todd, Scott R Rudge, Demetri P Petrides	Oxford University Press	2nd edition, 2015
2	Bioseparations: Principles and Techniques	B. Sivasankar	Prentice Hall of India	1st edition, 2010
3	Principles of Fermentation Technology	Peter F Stanbury, Allan Whitaker, Stephen J Hall	Butterworth-Heinemann	3rd edition, 2017
4	Bioprocess Engineering Principles	Pauline M Doran	Elsevier Academic Press	2nd edition, 2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Comprehensive Biotechnology	Murray Moo-Young	Elsevier	2^{nd} edition, 2011
2	Biotechnology: a multi-volume comprehensive treatise (Volume-8 Bioprocessing)	Hans-Jurgen Rehm, Gerald Reed	VCH-Weinheim	1^{st} edition, 1991
3	Separation Processes in Biotechnology	Juan A Asenjo	CRC Press	1^{st} edition, 1990
4	Bioseparations: Downstream Processing for Biotechnology	Paul A Belter E L Cussler Wei-Shou HU	Wiley-Blackwell	1^{st} edition, 1988

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL video on Principles of Downstream Techniques in Bioprocess by Prof. Mukesh Doble, IIT Madras.
2	
3	
4	

SEMESTER S5

HEAT & MASS TRANSFER OPERATIONS LAB

Course Code	**PCBBL507**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge On Various Unit Operations	**Course Type**	Lab

Course Objectives:

1. To understand the principles of various modes of heat transfer and Mass Transfer Operations
2. To familiarise the operations and working of various heat and Mass transfer equipment.

Minimum of 12 experiments are to be conducted

Expt. No.	Experiments
1	Heat Transfer by Natural Convection
2	Heat Transfer by Forced Convection
3	Thermal conductivity of Metal Rod
4	Heat transfer through Composite Wall
5	Heat transfer in Double pipe heat exchanger
6	Heat Transfer in Shell and Tube Heat Exchanger
7	Emissivity Measurement Apparatus
8	Heat Transfer in Fins
9	Unsteady State Heat Transfer
10	Determination of Critical Radius of Insulation
11	Combined Convection and Radiation Heat Transfer
12	Radiation Heat Transfer
13	Heat Transfer in Agitated Vessels
14	Drop and Filmwise Condensation
15	Any other experiment related to different modes of heat transfer with and without change of phase.
16	Diffusion coefficient measurement
17	Simple Distillation
18	Steam Distillation
19	Liquid extraction- Determination of Ternary liquid-liquid equilibria

20	Simple leaching-varying solvent to feed ratio
21	Simple leaching- varying number of stages
22	Cross current leaching
23	Counter current leaching
24	Adsorption Isotherm
25	Atmospheric batch drying
26	Wetted wall column-measurement of mass transfer coefficient
27	Any other experiments related to mass transfer operations applicable in Chemical Engineering.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply the fundamental knowledge of heat and mass transfer in related practical problems	**K4**
CO2	Evaluation of the heat and mass transfer coefficients.	**K5**
CO3	Analyse the working of heat and mass transfer equipment.	**K4**
CO4	Interpret and present the experimental data meaningfully.	**K3**
CO5	Develop teamwork skills.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2							3	1		
CO2	3	2							3	1		
CO3	3	3	2						3	1		2
CO4	3			3					3	1		
CO5									3	1		

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mass Transfer Operations	Robert E Treybal	McGraw Hill	3rd Edition 2017
2	Mass Transfer: Theory and Applications	K V Narayanan and B Lakshmikutty	CBS Publishers	2nd Edition 2023

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Heat Transfer: Principles and Applications	Datta B.K	Prentice Hall India	
2	Unit Operations in Chemical Engineering	McCabe W.L., Smith J.C. &Harriot P	McGraw Hill	
3	Heat Transfer	Hollman J.P	McGraw Hill	
4	Fundamentals of Engineering Heat and Mass Transfer	R C Sachdeva	New age International Publishers	
6	Principles of Unit Operations	Foust A.S. et. al.	John Wiley	2^{nd} Edition 1980
7	Chemical Engineering, Vol. II	Coulson J.M. & Richardson J.F.	ELBS, Pergamon.	5^{th} Edition 2002

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. **Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

3. **Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER S5

BIOPROCESS ENGINEERING LAB

Course Code	**PCBBL508**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Basic Knowledge in Process Engineering	**Course Type**	Lab

Course Objectives

1. To provide practical skills in handling and characterising biomolecules

Expt. No.	Experiments
1	Screening of process variables single dimensional search: Plackett-Burman design practice
2	Microbial cell growth kinetics: Growth of microorganisms, estimation of Monod parameters and temperature effect on growth-estimation of energy of activation and Arrhenius Constant for microorganisms.
3	Determination of volumetric mass-transfer coefficient (Kla) by dynamic method and sulphite oxidation method.
4	Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
5	Preparation and characterization of immobilized cell systems.
6	Determination of kinetic constants in free and immobilized cell systems- Evaluation of Effectiveness factor and Thiele modulus
7	
8	Cell lysis using Sonication.
9	Cell lysis using organic solvents
10	Comparison of flocculating power of different flocculants.
11	Determination of Isoelectric point of proteins and isolation of proteins from aqueous systems by pH change.
12	Organic salt mediated precipitation: Concentration of proteins from aqueous systems by addition of ammonium sulphate.

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Development of an ability to design and conduct bioprocess experiments as well as to analyse and interpret data.	**K3**
CO2	Calculate the kinetic parameters of microbial growth.	**K3**
CO3	Acquire knowledge in biochemical engineering reactions along with isolation and purification of desired products	**K2**
CO4	Development of research attitude and technical skills to secure a job in bioprocess labs.	**K5**
CO5	Exhibit ethical principles in the engineering profession by practicing ethical approaches in experimental investigation, collection and reporting of data and adhering to the relevant safety practices in the laboratory.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	3	2	-	-	3	3	3	3	-
CO2	3	3	-	3	-	-	-	-	-	-	-	-
CO3	3	3	-	3	2	-	-	-	-	-	-	-
CO4	3	3	-	3	2	-	-	3	3	3	-	3
CO5	3	3	-	3	-	-	-	3	-	-	3	-

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biochemical Engineering Fundamentals	Bailey, J.E. and Ollis, D.F	McGraw Hill	1986
2	Bioprocess Engineering Principles	Doran, P.M	Academic Press	2012
3	Bioseperations Downstream Processing for Biotechnology,	P A Belter, EL Cussler, Wei-Shou Hu	Wiley	1988

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Fermentation Technology	Stanbury P. F., Whittaker, A. and Hall, S. J.	Butterworth-Heinemann	2007
2	Bioprocess Engineering: Basic Concepts	Shuler M., Kargi F.	PHI	2012

Continuous Assessment (25 Marks)

1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

2. Conduct of Experiments (7 Marks)

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

3. Lab Reports and Record Keeping (6 Marks)

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

4. Viva Voce (5 Marks)

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

2. Conduct of Experiment/Execution of Work/Programming (15 Marks)

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

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

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

4. **Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

5. **Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 6

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

SEMESTER S6

PROCESS DYNAMICS CONTROL & INSTRUMENTATION

Course Code	**PCBBT601**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:1:0:0	**ESE Marks**	60
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Students will be learning the latest technologies in food processing and its applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to process control with the help of examples of a tank heater system-** different control strategies- feedback, feed forward, inferential. **General modeling principles-** Classification of variables in process control. Importance of state variables, state equations and degrees of freedom **Tools for solving models-** Laplace Transforms: Definition of the Laplace transform. Laplace transforms of some basic forcing functions - step, exponential, ramp, sinusoidal, cosine, pulse, impulse and translated functions, Laplace transform of derivatives and integrals, initial value theorem and final value theorem. Numerical problems **Example-** Theoretical model development of tank heater system – input-output model and its solution.	11
2	**Transfer functions and their general characteristics -** Transfer functions of SISO systems - A general first order and second order systems. **Development of transfer function models for first order systems -** First order systems and its general characteristics, Development of transfer function models for first order systems- a continuous single tank (mass	11

	storage) system and a mercury in glass thermometer system (only linear systems). Dynamics of a first order system for step and impulse input. **Development of transfer function models for second order systems –** multi-capacity systems - two tanks connected in series, inherently second order systems - damped vibrator, first order system in the presence of a controller. Dynamics of second order systems - General characteristics of under damped, over damped and critically damped systems. **Numerical problems –** Numerical Problems on overshoot, decay ratio, period of oscillation, ultimate value and maximum value. Numerical problems on transfer functions and dynamic response of first and second order systems	
3	**Hardware elements of a control system-** Explanation with the help of an example temperature control set up for a bioreactor. **Instrumentation -** Final control elements, Measuring devices for flow, temperature, pressure, level, pH, Dissolved Oxygen **Transfer function of components of feedback loop -** Transfer functions of measuring devices, transmission lines and final control elements (pneumatic control valves and control valve characteristics). Dead time processes. Types of feedback controllers. Control laws and transfer functions of P, PI and PID controllers. **Dynamic behaviour of feedback-controlled processes**. Difference between open loop and closed loop control system. Closed loop transfer function for feedback (positive and negative) processes. Servo and regulatory responses due to the presence of proportional control, integral control, derivative control action and composite control on the response of a feedback-controlled process.	**11**
4	**Frequency response characteristics using substitution rule and their graphical representations -** General linear system, dead time process, pure capacitive process, feedback controllers-P, PI, PD and PID controllers. (General representation of frequency response of typical transfer functions using BODE plot is only expected and no problems are expected) **Stability analysis of feedback systems**: Notion of stability, Stable and unstable systems, BIBO stability, Prediction of stability of transfer function for open loop and closed loop systems based on transfer function analysis. The characteristic equation, Routh Hurwitz criterion for stability. Cross over frequency, Gain and Phase margin. Bode stability criterion, Nyquist stability criterion. Numerical examples on Routh analysis, Cross over frequency, GM,	**11**

	PM. **Design of feedback controllers**: Semi empirical tuning techniques -CC and ZN Tuning. Numerical problems based on semi empirical tuning rules. **Introduction to other methods of Controller tuning-** Internal Model Control (IMC) Tuning, Model Predictive Control (MPC), Fuzzy Logic PID Tuning, Adaptive PID Control (No detailed study is required on these topics. A basic overview would be sufficient)	

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	*Internal Ex*	*Evaluate*	*Analyse*	*Total*
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE):
In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Illustrate the design elements and hardware elements of a process control system	**K2**
CO2	Model simple systems and solve the mathematical equations using Laplace transforms	**K3**
CO3	Determine the dynamic behaviour of both open and closed loop systems	**K3**
CO4	Design conventional type of controllers for stable operation using selected mathematical method	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										
CO2	2	2										
CO3	2	2			2							
CO4	2	2	2		2							

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Chemical Process Control: An Introduction to Theory and Practice	Stephanopoulose G	Pearson Education India Edition	First Edition
2	Process Systems Analysis and Control	Coughanowr R D, LeBlanc E S,	McGraw Hill International Edition	Third Edition
3	Industrial Instrumentation	Eckman	CBS Publishers and Distributors Pvt Ltd	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Process Modeling Simulation and Control for Chemical Engineers	Luyben W L	McGraw Hill, Singapore	Second Edition
2	Process Dynamics and Control	Seborg D E, Edgar TF, Mellichamp D A, Doyle FJ	John Wiley & Sons	Third Edition
3	Process Control	Peter Harriot	McGraw Hill Education	
4	Principles of Fermentation Technology	P F Stanbury, A Whitaker and S J Hall	Butterworth-Heinemann	Third Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/105/103105064/ https://nptel.ac.in/courses/103103037
2	https://archive.nptel.ac.in/courses/103/105/103105064/ https://nptel.ac.in/courses/103103037
3	https://archive.nptel.ac.in/courses/103/105/103105064/ https://archive.nptel.ac.in/courses/103/105/103105130/ https://nptel.ac.in/courses/103103037
4	https://archive.nptel.ac.in/courses/103/105/103105064/ https://nptel.ac.in/courses/103103037

SEMESTER S6

PROCESS PLANT DESIGN

Course Code	PCBBT602	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge in Unit operations, Chemical Reaction Engineering and Heat & Mass Transfer Operations	Course Type	Theory

Course Objectives:

1. To give a foundation for the undergraduates in the design of equipment used in process industries for distillation, gas absorption, evaporation and heat exchanger
2. To familiarise mechanical design of tall equipment by applying basic principles of mechanics.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Process design of steady state isothermal binary component tray distillation columns (Sieve and valve tray):** Estimation of theoretical number of stages using McCabe Thiele method –Tray design – tray efficiency - pressure drop, entrainment, downflow flooding and weeping. **Process design of steady state isothermal packed bed absorption and stripping column for dilute systems without chemical reaction:** Number of transfer units- height of transfer units – column diameter – packing height-liquid distribution-pressure drop. **Design of fermenters**: Design considerations for maintaining sterility of process streams and process equipment.	18
2	**Design of heat exchange equipment for upstream and downstream operations in bioprocessing industries:** Estimation of number of pipes used for hairpin structure – check thermal design and momentum transfer Estimation of number of tube and shells are used different shell and tube heat exchangers	18

	Design and drawing of various types of evaporators employed in bioprocess operation: Evaporators: (Standard vertical tube evaporator) estimation of heat transfer area- diameter of calandria – diameter and height of vapour release chamber **Mechanical design of tall pressure vessels:** design of thin walled multi-course pressure vessels as per IS 2825 – Estimation of thickness of shells subject to internal and external loads –Selection and design of flat plate, tori spherical, ellipsoidal, and conical closures, compensations of openings.	

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)	Total
2 numerical questions will be given from each module, out of which 1 question should be answered. The questions in each module shall be from different topics. Each question carries 30 marks. **(2x30 = 60 marks)**	**60**
The questions should be clear in respect of type of equipment, operating conditions, materials handled and objective. Data required for design such as equilibrium data and physical properties in case it cannot be obtained from handbook/data book shall be provided with the question. Question paper should contain instruction as given below: • *Assume any missing data suitably.* • *Apart from scientific calculators the following books and data books are permitted for the exam (Photostat copies of the books are not permitted except the item no.2):* *1. Steam tables* *2. Perry's Handbook (Original or attested bound copy of Chapters 1,2,3,4,5,6,10,11,12,13,14 &15)* *3. Attested copies or original of IS Codes (2825, 1730, 4049)* *4. Attested copies of Psychrometric charts, Nomographs, charts and tables used in design taken from other editions of Handbook/References.* *5. Attested copy of Sieve tray hydraulics and sieve tray mass transfer for liquid extraction* *from 'Mass Transfer Operations' by Robert E. Treybal, pg 532-538.* *(The copies should be attested by the course faculty concerned or as directed by university.)* *No other textbooks or materials such as handouts, printed notes etc. are permitted for the exam.*	

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Design binary tray distillation column	**K3**
CO2	Design packed bed absorption column	**K3**
CO3	Design of heat exchanger	**K3**
CO4	Design single and multiple effect evaporator	**K3**
CO5	Design thin-walled unfired tall pressure vessels using Indian Standard codes	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	3			2		2				3
CO2	3	2	3			2		2				3
CO3	3	2	3			2		2				3
CO4	3	2	3			2		2				3
CO5	3	2	3			2		2				3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	IS Codes: 2825, 1730, 4049		BIS	
2	Chemical Engineers Handbook	Perry RH &GreenDW	Mc- Graw Hill.	7thEdn
3	Mass Transfer Operations	Robert E. Treybal	McGraw Hill Education	3rdEdn, 2017
4	Chemical Engineering, Vol.6	Coulson JM& Richardson JF	Butterworth Heinemann, (Indian print)	3rd Edn

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Process Equipment Design	MV Joshi & Mahajan VV	Mac-Milan & Co. India.	3^{rd}Edn,
2	Introduction to Chemical Engineering	Badger &Bancharo	McGraw Hill	
3	Introduction to Chemical Equipment Design	B.C Bhattacharya	CBS Publishers & Distributors, New Delhi.	2008
4	Unit Operations in Chemical Engineering	McCabe WL, Smith JC & Harriott P	McGraw Hill.	7^{th} Edn

SEMESTER S6

IMMUNOLOGY

Course Code	PEBBT631	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	Course Type	Theory

Course Objectives:

1. Acquire knowledge on types of immunity, cells, and organs of the immune system
2. Provide knowledge on essential features of antigen-antibody and their interactions
3. Explain the concept of hypersensitivity, autoimmunity, and transplantation.
4. Provide knowledge of immunological techniques.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction**: Scope of Immunology, Historical background of Immunology Haematopoiesis, Innate and Adaptive Immunity, Cells and organs of the Immune System. Forms of immune activity (immune response, immune non-reactivity)	9
2	**Antigens:** Essential features of Ag, haptens, Carrier molecule, Antigenic determinants. Adjuvants: Freund's complete and incomplete. **Antibodies**: Nature, Primary structure of immunoglobulins, Classification of Immunoglobulins: Types –IgG gM, IgA, IgD and IgE, Immunological memory, Immune tolerance **MHC**: Types, structure, function, **Complement Pathways**-Types and functions	9

3	**Hypersensitivity (HS)**: **Type I**: Allergies and anaphylaxis **Type II:** Haemolytic disease of new born (HDN). **Type III**. Soluble immune complexes and insoluble immune complex-mediated reactions. **Type IV**: Delayed type (or) cell-mediated HS reactions; Tuberculin reaction. **Autoimmunity**: Introduction, Auto recognition, classes of autoimmune diseases. (Hashimoto disease, thyrotoxicosis, Systemic lupus erythematosus, Rheumatoid arthritis **Transplantation:** Terminology, Auto graft, Isograft, Allograft, Xenograft, Immunological basis of transplantation reactions (Role of T & B cells) **Immune suppression**, drugs (azathioprine, methotrexate, cyclophosphamide, cyclosporin-A, Steroids)	**9**
4	**Immune response to infection;** immune response to bacteria and viruses **Immunotechnology**: Antigen-antibody interaction (Precipitation and agglutination reaction), Immunoelectrophoretic, RIA, western blot, ELISA, immunohistochemistry – Introduction and Basics	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	**Assignment/ Microproject**	**Internal Examination-1 (Written)**	**Internal Examination- 2 (Written)**	**Total**
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Elaborate on various types of immunity and components of the immune system	**K2**
CO2	Interpret the role of the immune system in hypersensitivity, autoimmunity, and transplantation	**K3**
CO3	Illustrate the basis of immunological tolerance and how the complex network of immune functions contributes to host defense.	**K2**
CO4	Apply the concepts of immune technology in diagnosis and treatment	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										2
CO2	3	2										2
CO3	3	2					2					2
CO4	3	2										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Immunology	Janis Kuby, Thomas J. Kindt, et al	W H Freeman	8th edition 2006
2	Roitt's Essential Immunology	Seamus J. MartinDennis R. Burton Ivan M. Roitt Peter J. Delves	Wiley	13th edition 2017
3	Text Book of Immunology	Basir F	Eastern Economy	2nd edition 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Immunology: A Short Course	Geoffrey Sunshine, Richard Coico	Wiley	7th edition, 2015
2	Microbiology An Introduction	Tortora, Funk and Case	Pearson	13th edition, 2021
3	Textbook Of Immunology Including Immunotechnology & Immunotherapy	Ajoy Paul	Books and Allied	1st edition 2018

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1, 2, 3 & 4	NPTEL :: Http://digimat.in/nptel/courses/video/102105083/L57.html https://onlinecourses.nptel.ac.in/noc24_bt24/preview NPTEL :: http://digimat.in/nptel/courses/video/102105083/L51.html https://onlinecourses.nptel.ac.in/noc24_bt24/preview

SEMESTER S6

NANO BIOENGINEERING

Course Code	PEBBT632	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. Students will acquire necessary knowledge and skills in the frontier areas of nano Bioengineering
2. Students will be able to implement the bioengineering principles to Nano biotechnology

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Nano Bioengineering, Organic and inorganic, Nanomaterials Nanostructures and Dynamics of Biocompatible surfactant monolayers and bilayers Bio-interface, Bioconjugation, Bio-matrix based on bioinspired phospholipids polymers. Self-assembly of ionic-complementary peptides and their applications	9
2	Nano biotechnology from nanocluster assays to optical biochips for nanobiotechnology bioactive nanomaterials in bone grafting and tissue engineering- inorganic polymer nano composites for dental restoration and bone replacement applications. DNA based artificial nanostructures: fabrication, properties and applications. Nucleic acid engineered nanomaterials and their applications- RNA, DNA	9
3	**Nanotechnology in medicine-** Nanomedicines for various disease conditions: infectious diseases, neurological diseases, pulmonary disorders, cardiovascular diseases, cancer: nano-chemotherapy, -radiation therapy, -immunotherapy, -nuclear medicine therapy, -photodynamic therapy, -	9

	photothermal and RF hyperthermia therapy, gene therapy. Drug targeting strategies for site-specific drug delivery-passive and active targeting, time and rate-controlled drug delivery, Nanotoxicity- Experimental Models in Nanotoxicology- In vitro Models, In Vivo Models, Predicting Penetration and Fate of Nanoparticles in the Body, Toxicity Mechanisms..	
4	**Introduction to BioMEMS** - Bio- microelectromechanical systems (Bio-MEMS), cell manipulations, Microfluidics: Introduction, properties of biological fluids in microchannels, devices, Lab-on-a-Chip: Microanalytical systems in chemistry and biology, MEMS Implants and Bioelectric Interfaces: Implantable microelectrodes, shunts	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the challenges and opportunities associated with biology on the nanoscale, as well as the characteristics and applications of biologically relevant molecular nanostructures	**K1**
CO2	Apply the knowledge of biomolecules for designing nanostructures by understanding the principles of self-assembly and self-organization and apply them to biology	**K3**
CO3	Evaluate different nanomedicines used for various disease conditions, assess the drug targeting strategies, and understand the nanotoxicity mechanisms.	**K5**
CO4	Critically analyze the role of Bio-MEMS in various applications and assess their impact on healthcare and biomedical research.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2				2	2					2
CO2	3	2	1	1		2	2					2
CO3	3	2	1	1		2	2					2
CO4	3	2	1	1		2	2					2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biological and pharmaceutical nanomaterials	Challa S.S.R. Kumar (Ed)	Wiley – VCH Verlag GmbH& Co, KgaA.	2018
2	Handbook of Nanostructured Biomaterials and their applications in Nanobiotechnology	H.S. Nalwa	American Scientific Publishers	2005
3	Essential of Stem Cell Biology	R. Lanza, J. Gearhart et al	Elsevier Academic press.	2009
4	Tissue Engineering	Palsson, B.O. and Bhatia, S	Pearson Prentice Hall	2004.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Biochemistry 4th Edition ISE	Voet & Voet	Publisher Wiley	
2	Handbook of Stem Cells	R. Lanza, I. Weissman, J. Thomson, and R. Pedersen	Academic Press	2012
3	Tissue Engineering	Pallua, N. and Suscheck, C.V	Springer	2010

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc22_mm33/preview
2	
3	https://onlinecourses.nptel.ac.in/noc21_bt30/preview
4	https://archive.nptel.ac.in/courses/118/107/118107015/

SEMESTER S6

INNOVATION & ENTREPRENEURSHIP

Course Code	PEBBT633	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	Course Type	Theory

Course Objectives:

1. To develop the creativity skills among the learners
2. To impart the knowledge of creative intelligence essential for entrepreneurs
3. To know the applications of innovation in Entrepreneurship
4. To develeop innovative business models for business.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to innovation and idea development: Introduction to Innovation, managing innovation, types of innovation, creativity, concept of design thinking, measuring innovation, Novelty -definition, identification Protection of innovation - Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights, grassroots innovation, Issues and Challenges in Commercialization of Technology Innovations. Concept of novelty and inventive steps in biotechnology. Patent laws related to microbial, pharmaceutical, environmental and agricultural inventions, case studies in public health	9
2	Entrepreneurship basics – scope of entrepreneurship, characteristics of an entrepreneur, building a business, business plan, concept of lean canvas model, Entrepreneurship and Innovations, Converting Innovation to Economic Value - Growth Strategies, value proposition, Market Segments, Revenue Model, Social Entrepreneurship, Intrapreneurship, biotechnology entrepreneurship case studies	9

3	Technology product development, Technology Life Cycle, how to implement and manage a technological innovation, new product development, managing the resources, technology business incubation, Sources of Information and schemes to support technology entrepreneurship, overview of the steps involved in the technology development in biotechnology.	9
4	Functional areas of entrepreneurship - marketing management, operations management, personnel management, financial management, procedure and formalities in setting up an Industrial unit, Problems for Small Scale Enterprises and Industrial Sickness. Site visits to understand the Entrepreneurship activities of startups.	9

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Build knowledge about Sources of Information and Support for Entrepreneurship	**K2**
CO2	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business incubation	**K2**
CO3	Develop and strengthen entrepreneurial quality and motivation in students and to impart basic entrepreneurial skills and understanding to run a business efficiently and effectively.	**K5**
CO4	Identify and evaluate new business opportunities in biotechnology.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				3	3	3	1	1	2	3
CO2	3	3				3	3	1	1	2	2	3
CO3	3	3				3	3	1	1	2	2	3
CO4	3	3				3	3	1	1	2	2	3

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	The Law & Strategy of Biotechnology Patents	K.D. Sibley	Butterworth-Heinemann, 1994	1994
2	"Entrepreneurship" 8th Edition	Hisrich R D, Peters M P,	Tata McGraw-Hill, 2013	2013
3	Entrepreneurship: New Venture Creation	Holt David H	Pearson Education, 2016	2016
4	Entrepreneurship Development in India,	Debasish Biswas, Chanchal Dey	Taylor & Francis	2021
5	Management of Technology,	Tarek Khalil	Tata McGraw-Hill	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Entrepreneurship: Successfully launching new ventures,	Barringer, B. R.	Pearson Education	2015
2	Small-Scale Industries and Entrepreneurship.	Desai, Vasant	Himalaya Publishing House, Delhi. 2008	2008
3	Entrepreneurship: Theory, Process, Practice.	Donald F. Kuratko,	Cengage Learning India, Delhi, 2017	2017
4	Entrepreneurship Ideas in Action.	Cynthia, L. Greene	Thomson Asia Pvt. Ltd., Singapore. 2004	2004

SEMESTER S6

CLINICAL RESEARCH AND DRUG DESIGN

Course Code	**PEBBT634**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	none	**Course Type**	Theory

Course Objectives:

This course will enable students to

1. To understand the terminologies and basic principles of pharmacokinetic and pharmacodynamic involved in the use of drugs.
2. To know the therapeutic uses and adverse effects of common drugs used for different disease conditions, ethical constrains, etc

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction and History of Clinical research, Clinical Trial Terminologies, CPCSEA Guideline & Pre-clinical Trials, Introduction to Toxicity Studies, Drug Discovery & Development, Definition of clinical trial, Different Phases of clinical research, Sub-types of Phases 1,2 and 3, Phase 4, Bio-availability & Bio-equivalence Studies [BA/BE], E –clinical trial.	9
2	Drug Regulations & Ethics in Clinical Research, Background of ethics, Nuremberg code, Declaration of Helsinki, Belmont Report, Informed consent Process, History of Indian regulations, Schedule–Y-Appendices, ICMR Guidelines, Indian GCP, ICH GCP, Drugs & magic remedies Act 1954, Drug prices control order, Regulations for AYUSH, CTRI-Clinical trial registry of India.	9

3	Clinical Trial Documentation, Audits and Inspections, Different types of trial design, Clinical trial documents, Role of personnel in a clinical trial, Definition & responsibility of Principal Investigator, Objectives and Role of Clinical Research Organization, Site Management and Monitoring in Clinical Research. An Introduction to Clinical Data Management, Data Management Standards, Set-Up, CDMS & CTMS, Conduct, Medical coding / Writing, Close Out, Pharmacovigilance.	**9**
4	Types of drug testing: oral, urine, blood, hair, perspiration and breathalyzers. Techniques used for Drug Testing. UV and visible spectrophotometry, Fluorimetry, IR spectrophotometry, NMR, 13c NMR, Mass Spectrometry, Flame Photometry, Emission Spectroscopy, Atomic Absorption Spectroscopy, X -ray Diffraction, Radio immunoassay, GC, GC-MS, IRMS.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the history of clinical research and different phases of clinical research studies	**K2**
CO2	Understand the drug regulation and ethics	**K2**
CO3	Understand Clinical trial documentation, clinical research data management	**K2**
CO4	Apply the major techniques used for the product purification	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	-	-	-	-					
CO2	1	-	-	-	-	-	-					
CO3	2	2	-	-	2	-	-					
CO4	2	3	2	3	-	-	-					

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Clinical Research Coordinator Handbook, Fourth edition	Norris, Deborrah	Plexus Pub	2018
2	Drug testing 1st edition	John Fay	Butterworth-Heinemann	2014
3	Handbook of drug monitoring methods therapeutic and drug abuse, Third edition	Amitava Dasgupta	Humana Press Inc.	2007
4	Practical guide of clinical data management, Third edition	Susanne Prokscha	Taylor and Francis Inc	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Essential Concepts In Clinical Research	Schulz K F	Elsevier	2019
2	Designing Clinical Research	Alison J Huang, Alka m. Kanaya, MPH Grady, Deborah G, MD et.al	Wolters Kluwer Health	2022

SEMESTER S6

BIOPHARMACEUTICAL TECHNOLOGY

Course Code	**PEBBT636**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	**Course Type**	Theory

Course Objectives:

1. The subject will give exposure of fundamental knowledge in biopharmaceutical Technology for students to make their career in pharmaceutical industries.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Different Pharmacopoeia, IP, BP, EUP, USP, Quality Control Standards, Standard Operating Procedure, GMP, cGMP, Quality analysis: QC, QA, Documentation, Market complaint analysis. USFDA, WHO, Patenting of Pharmaceutical products. Role of regulatory authorities in the biopharmaceutical industry.	9
2	Production of Biopharmaceuticals: Drug Discovery Process, Sources of drugs: Plants, Animals and Microbes. Current status and future prospectus. Approaches in drug design. Impact of genomics and related technologies in drug discovery. Delivery of biopharmaceuticals. Packaging and transport of biopharmaceutical products.	9
3	Downstream process: Techniques used for the product purification (HPLC, HPTLC, Column Chromatography, Gel Filtration, Centrifugation) Immunogenicity of biopharmaceuticals: Immunogenicity, Immunogenicity valency, Methods of factors contributing to immunogenicity valency 10 (product-related factors, host-related factors), Consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity	9

4	ADME, Case studies, Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocytemacrophage-CSF, DNase, Factor VIIA, Factor IX, Factor VIII, Activated protein C, Tissue plasminogen activator, Monoclonal antibodies, Biosimilars - Advances and challenges.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the discovery and regulatory process of biopharmaceuticals	**K2**
CO2	Discern the production, processing, packaging and transport of drug molecules	**K2**
CO3	Ascertain the use of various therapeutic proteins, antibodies and vaccines	**K3**
CO4	Analyze case study and industrial production of therapeutic proteins	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3										2
CO3	3	3										2
CO4	3	3	2									2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biopharmaceuticals: Biochemistry & Biotechnology", 2nd Edition	Gary Walsh	Wiley Publications	2018
2	An Essential Guide to Biopharmaceuticals	David Aebisher	Nova Publications.	2015
3	"Biopharmaceuticals, an Industrial Perspective, 1st Edition	Gary Walsh	Springer.	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Biopharmaceuticals: Recent Success Stories, 1st Edition	Jörg Knäblein	Wiley Blackwell Publications.	2020
2	Biopharmaceuticals: Challenges and Opportunities1st Edition	Dr. Basanta Kumara Behera	CRC Press.	2015

SEMESTER S6

TRANSPORT PROCESSES IN BIOLOGICAL SYSTEMS

Course Code	**PEBBT635**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PCBBT403, PCBBT501, PCBBT503	**Course Type**	Theory

Course Objectives:

1. To provide an insight into the the basic principles and applications of the transport phenomena of momentum, heat and mass transfer in biological systems.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Momentum Transfer: Generalization of Newton's law of viscosity,pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases. General transport equations for momentum - derivation of continuity equation and equation of motion in rectangular coordinates. Shell momentum balance- boundary conditions - application of shell balance to simple flow systems - flow of a Newtonian fluid in the space between two parallel plates - flow through annulus - flow of two adjacent immiscible fluids. Shell momentum balance for blood flow in capillaries and porous tissues.	9

2	Heat Transfer: Thermal conductivity and the mechanism of energy transport-prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases and liquids, relationship between thermal conductivity and viscosity of gases. Shell energy balance - boundary conditions - application of shell balance to heat conduction problems to derive temperature and heat flux profiles - conduction with electric, and viscous heat sources. Temperature profile in tissues.	**9**
3	Mass Transfer: Diffusivity and the Mechanism of Mass Transport, Definition of concentrations, velocities and mass/molar fluxes, interrelationship between fluxes. Fick's law of diffusion, Prediction of diffusivity of gases, effect of temperature, pressure, and composition on diffusivity of gases and liquids, analogies between heat, mass, and momentum transfer. Shell mass balance - boundary conditions - diffusion through stagnant gas - diffusion with heterogeneous and homogeneous chemical reaction, equation of continuity for binary mixtures in rectangular coordinates.	**9**
4	Significance and applications: Mass transfer coefficients and theories of mass transfer, Oxygen transport to microbial cultures, Mass transport in porous tissues, Transport of gases between blood and tissues, Oxygen-haemoglobin binding kinetics and equilibria, Oxygen transport in lung capillaries and to tissues, Shell mass balance and boundary conditions for transport of O_2 and CO_2 in the lungs, Pharmacokinetic analysis- one and two compartment models, drug transport in solid tumors.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Summarize the principles of momentum, heat and mass transfer	**K2**
CO2	Demonstrate simple problems involving isothermal steady state momentum transfer using shell momentum balance, equations of change and boundary conditions.	**K3**
CO3	Interpret analytical solutions of selected engineering steady state problems of heat transfer using shell energy balance and equations of change.	**K3**
CO4	Execute simple steady state diffusion problems using shell mass balance	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3										2
CO3	3	3										2
CO4	3	3										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Transport Phenomena	R.B.Bird,Stewart W.C, Light Foot.F. N	John Wiley & Sons	2nd Edition, 2006
2	Transport Processes and Unit Operations	Geankoplis	Prentice Hall of India	3rd Edition, 1997
3	Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer and Mass Transfer Applied to Biological Systems	Arthur T Johnson	John Wiley & Sons	1999
4	Fundamentals of Momentum, heat and Mass Transfer	Welty, Wicks, Wilson, Rorrer	John Wiley & Sons	5th Edition, 2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioprocess Engineering Fundamentals	Pauline M Doran	Academic Press	2nd Edition, 2013
2	Biochemical Engineering	Blanch H W, Douglas S C	CRC Press	2nd Edition, 1997
3	Bioprocess Engineering: Basic Concepts	Michael L Shuler & Fikret Kargi	Prentice Hall of India	2nd Edition, 2015

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1, 2, 3 & 4	https://archive.nptel.ac.in/courses/102/106/102106083/ https://archive.nptel.ac.in/courses/102/106/102106083/ https://archive.nptel.ac.in/courses/102/106/102106083/ https://archive.nptel.ac.in/courses/102/106/102106083/

SEMESTER S6

BIOINFORMATICS

Course Code	PBBBT604	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	40
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge on Molecular Biology and Cell Biology	**Course Type**	Theory

Course Objectives:

1. To launch the Bioinformatics core concepts to students.
2. To provide knowledge on Biological databases, sequence analysis,evolutionary analysis and applications of Bioinformatics.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Bioinformatics and Biological Databases Introduction to Bioinformatics: definitions, historical overview, applications and scope, Biology to understand the Bioinformatics – Important Biological Databases: Retrieving and analyzing data from biological databases, Genbank, NCBI, DDBJ, Pubmed, UniProt, PROSITE, SCOP, RCSB-PDB, EMBL-EB	9
2	Sequence Alignment and Phylogenetics Analysis Sequence alignment tools and algorithms: Substitution matrices, PAM, BLOSUM, Gap penalties, pairwise sequence alignment using Dynamic Needleman-Wunsch, Smith-Waterman, and Heuristic programming algorithms, FASTA and BLAST-Multiple sequence alignments: Common multiple alignment methods, CLUSTALX, identification of motifs and patterns, Hidden Markov model-Phylogenetic Analysis: Elements of phylogenetic models, Determining the substitution model tree, Evaluating phylogenetic trees	9

3	Structure Prediction and Analysis Predictive methods, Codon bias detection, Modular nature of proteins - Protein identity based on the primary, secondary, and tertiary structure of proteins, protein homology modeling, Bioinformatics approaches for Molecular modeling in drug discovery, Protein-Protein interactions	**9**
4	Data Analysis and Interpretation High throughput sequencing and data analysis: Human Genome Project, Next generation sequencing, Detection of SNPs and their relevance, Detection of functional sites in the DNA sequences, Gene predictions, Microarray data analysis, Gene expression analysis	**9**

Project-Based Learning: Bioinformatics (9 hrs)

1. In the first class before starting the first module, direct and help the students to select a suitable topic under bioinformatics are for enhanced drug discovery process**.** Drug discovery**,** bioinformatic**s** enables the efficient analysis and interpretation of large-scale biological data, facilitating target identification, lead compound optimization, and prediction of drug-target interactions. It aids students in the identification and characterization of potential drug targets through genomic and proteomic analyses.

2. Overall, this project will provide students with a comprehensive understanding of bioinformatics, and their potential applications in pharmaceutical and various other industries. It will also provide hands-on experience in the field of bioinformatics Project-based learning is considered successful only after the completion of the project and submission of the report to the faculty

Course Assessment Method
(CIE: 60 marks , ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 2 marks **(8x2 =16 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 sub-divisions. • Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Utilize the available online biological databases to retrieve and analyze sequences.	**K2**
CO2	Analyze the basic algorithms for sequence analysis of proteins and nucleic acids.	**K4**
CO3	Develop an idea about the predictive methods for the structure and function of any given nucleic acid and protein sequences based on sequence homology.	**K5**
CO4	Apply bioinformatics approaches to solve biological problems, such as gene annotation, molecular evolution, and drug designing.	**K3**
CO5	Critically evaluate the results of bioinformatics analyses and their biological significance	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	3	3	3	3	1	1	2	3
CO2	3	3	2	2	3	3	3	1	1	2	2	3
CO3	3	3	2	2	3	3	3	1	1	2	2	3
CO4	3	3	2	2	3	3	3	1	1	2	2	3
CO5	3	3	2	2	3	3	3	1	1	2	2	3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Bioinformatics	Arthur K. Lesk	Oxford University Press	5th Edn, 2019
2	Bioinformatics and Functional Genomics	J. Pevsner	Wiley-Blackwell	3rd Edn, 2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Comparative Gene Finding: Models, Algorithms and Implementation	M. Axelson-Fisk	Germany: Springer London	2nd Edn, 2015
2	Bioinformatics: Sequence and Genome analysis	D.W. Mount	Cold Spring Harbor Laboratory Press	2nd Edn, 2004
3	Statistical Analysis of Next Generation Sequencing Data.	S. Datta, D. Nettleton	Springer International Publishing	1st Edn 2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt06/preview

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**
   - Clarity and feasibility of the project plan
   - Research and background understanding
   - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**
   - Individual contribution to the presentation
   - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**
   - Active participation and individual contribution
   - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**
   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**
   - Quality and clarity of the overall presentation
   - Individual contribution to the presentation
   - Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**
   - Overall quality and technical excellence of the project
   - Innovation and originality in the project
   - Creativity in solutions and approaches

SEMESTER S6

FUNDAMENTALS OF FOOD PROCESSING

Course Code	**OEBBT611**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Students will be learning the latest technologies in food processing and its applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction and HPP Introduction to Food Process Engineering** Scope and importance. High Pressure processing – principle, equipment and process of HPP treatment, Application of HPP in food processing.	9
2	**Membrane Technologies and PEF** Membrane technologies in food processing – Overview of Membrane technology. Microfiltration, Ultra filtration (UF), Nano filtration(NF) and Reverse Osmosis (RO) and theirindustrial applications. Pulsed electric field processing - Principle, process and application in food processing sector	9
3	**Ultrasonic processing** Properties and application of ultrasonic processing techniques. Microwave and radio frequency processing. Ohmic heating, IR heating, dielectric heating and Food irradiation, Effects on foods Applications of irradiation.	9
4	**Hurdle technology and Nanotechnology** Hurdle technology - Concept of hurdle technology and its application. Nanotechnology, its principles and applications in foods	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	***Internal Ex***	***Evaluate***	***Analyse***	***Total***
5	**15**	**10**	**10**	**40**

Criteria for Evaluation(Evaluate and Analyse): 20 marks

1. **Problem Definition (2 points)**
   - Check for clarity and completeness of the problem definition.
   - Check for clear objectives and divide into sub objectives
2. **Problem Analysis (4 points)**
   - Examine the problem and identify the variables and responses
   - Divide the problem to manageable parts
3. **Implementation of software (2 points)**
   - Use suitable software for getting the solution
   - Check for the appropriateness of tools used
4. **Evaluate (4 points)**
   - Evaluate the proposed solution.
   - Assess the correctness of solution.
5. **Validation of the results (4 points)**
   - Validate the results using available data.
   - Do the error analysis of the results obtained.
6. **Conclusion and presentation (4 points)**
   - Summarize the results obtained
   - Do critical thinking of the results obtained and evaluate.
   - Submit a technical report

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Carry out the high-pressure processing in food industry	**K2**
CO2	Explain in detail about all membrane technology so that it can be applied in processing industry.	**K2**
CO3	Process the food items through novel heating methods.	**K3**
CO4	Apply nanotechnology to food processing to produce novel foods.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	1	-	-	-	-	-	-	-
CO2	3	3	2	-	1	-	-	-	-	-	-	-
CO3	3	2	2	-	2	-	-	-	-	-	-	-
CO4	3	2	3	-	1	-	-	-	-	-	-	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Food processing Handbook,	James G Brennan, Alistair S Grandison (Ed.),	Wiley – VCH	2011
2	Introduction to Food Process Engineering	P G Smith	Springer	2011
3	Food process engineering and technology	Zeki Berk	Elsevier	2013

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Transport Processes and Separation Process Principles	Geankoplis, C.J.	Prentice Hall	4th Edition, 2003
2	Coulson & Richardson's Chemical Engineering Vol.2 (Particle Technology & Separation Processes")	Richardson, J.E. et al	Butterworth – Heinemann / Elsevier,	5th Edition, 2003
3	Unit Operations in Chemical Engineering	McCabe W.L., Smith J.C.	McGraw – Hill Int.,	7th Edition,2001
4	Transport Processes and Separation Process Principles	Geankoplis, C.J.	Prentice Hall	4th Edition, 2003

SEMESTER S6

QUALITY CONTROL IN PHARMACEUTICAL INDUSTRY

Course Code	**OEBBT612**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Students will be learning the latest technologies in food processing and its applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Different Pharmacopoeia, IP, BP, EUP, USP, Quality Control Standards, Standard Operating Procedure, GMP, cGMP, Quality analysis: QC, QA, Documentation, Market complaint analysis. USFDA, WHO, Patenting of Pharmaceutical products. Role of regulatory authorities in the biopharmaceutical industry.	**9**
2	Production of Biopharmaceuticals: Drug Discovery Process, Sources of drugs: Plants, Animals and Microbes. Current status and future prospectus. Approaches in drug design. Impact of genomics and related technologies in drug discovery. Delivery of biopharmaceuticals. Packaging and transport of biopharmaceutical products.	**9**
3	Downstream process: Techniques used for the product purification (HPLC, HPTLC, Column Chromatography, Gel Filtration, Centrifugation) Immunogenicity of biopharmaceuticals: Immunogenicity, Immunogenicity valency, Methods of factors contributing to immunogenicity valency 10 (product-related factors, host-related factors), Consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity	**9**

4	ADME, Case studies, Erythropoietin, Insulin, Somatotropin, Interleukin-2, Interferon Granulocytemacrophage-CSF, DNase, Factor VIIA, Factor IX, Factor VIII, Activated protein C, Tissue plasminogen activator, Monoclonal antibodies, Biosimilars - Advances and challenges.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	***Internal Ex***	***Evaluate***	***Analyse***	***Total***
5	**15**	**10**	**10**	**40**

Criteria for Evaluation(Evaluate and Analyse): 20 marks

1. **Problem Definition (2 points)**
   - Check for clarity and completeness of the problem definition.
   - Check for clear objectives and divide into sub objectives
2. **Problem Analysis (4 points)**
   - Examine the problem and identify the variables and responses
   - Divide the problem to manageable parts
3. **Implementation of software (2 points)**
   - Use suitable software for getting the solution
   - Check for the appropriateness of tools used
4. **Evaluate (4 points)**
   - Evaluate the proposed solution.
   - Assess the correctness of solution.
5. **Validation of the results (4 points)**
   - Validate the results using available data.
   - Do the error analysis of the results obtained.
6. **Conclusion and presentation (4 points)**
   - Summarize the results obtained
   - Do critical thinking of the results obtained and evaluate.
   - Submit a technical report

End Semester Examination Marks (ESE):

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• 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 9 marks. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the discovery and regulatory process of biopharmaceuticals	**K1**
CO2	Discern the production, processing, packaging and transport of drug molecules	**K2**
CO3	Ascertain the use of various therapeutic proteins, antibodies and vaccines	**K3**
CO4	To know product-based case study and industrial production of therapeutic proteins	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	-	1	-	-	-	-	-	-	-
CO2	3	3	2	-	1	-	-	-	-	-	-	-
CO3	3	2	2	-	2	-	-	-	-	-	-	-
CO4	3	2	3	-	1	-	-	-	-	-	-	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Biopharmaceuticals: Biochemistry & Biotechnology", 2nd Edition	Gary Walsh	Wiley Publications	2018
2	An Essential Guide to Biopharmaceuticals	David Aebisher	Nova Publications.	2015
3	"Biopharmaceuticals, an Industrial Perspective, 1st Edition	Gary Walsh	Springer.	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Modern Biopharmaceuticals: Recent Success Stories, 1st Edition	Jörg Knäblein	Wiley Blackwell Publications.	2020
2	Biopharmaceuticals: Challenges and Opportunities1st Edition	Dr. Basanta Kumara Behera	CRC Press.	2015

SEMESTER S6

PROCESS DESIGN FOR POLLUTION CONTROL

Course Code	OEBBT613	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)		Course Type	Theory

Course Objectives:

1. Provide a comprehensive understanding of environmental regulations and pollution control principles.
2. Impart various technologies for wastewater treatment, sludge treatment and disposal, solid waste management strategies, air pollution management, and the abatement of noise& odour pollution to students.
3. Equip students with knowledge about preventing pollution in various industries, understanding emerging environmental challenges posed by new technologies like biotechnology and nanotechnology, and analysing historical industrial disasters such as the Bhopal tragedy.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Basics of Pollution Control -** Environmental Regulations and Standards: National regulations, Key legislations. Pollution Control Strategies - End-of-pipe treatments, Source reduction and waste minimization. **Wastewater Pollution and Treatment Methods -**Sources and classification of wastewater- Types of water pollutants and their effects. Treatment methods(brief overview- diagram, principle and working of equipment only) - Physical Treatment Methods: Screening, grit removal, Sedimentation, flotation, filtration, Chemical Treatment Methods: Coagulation, flocculation, precipitation, Biological Treatment Methods: Activated sludge, biofilm reactors, anaerobic digestion.	9

2	**Sludge Treatment and Disposal** - sludge thickening - sludge conditioning - sludge dewatering - sludge digestion and composting (brief overview). **Solid Waste Treatment**-sources and classification, disposal methods-open dumping, sanitary landfill, incineration-composting (brief overview). **Noise pollution–**Sources, effects of noise on people, noise control methods.	9
3	**Air Pollution:** Units of measurement, sources, classification. Sampling and analysis of air pollutants, health effects of air pollution global warming and ozone depletion. **Devices for Particulate Contaminants:** Gravitational settling, Centrifugal Collectors, Wet Collectors, Fabric filters and Electrostatic Precipitators (ESP) **Control Devices for Gaseous Contaminants**: Adsorption, Absorption, Condensation, Combustion, Automobile Emission Control. **Odour Pollution Management-**Sources, Health Impacts, Odour Measurement and Monitoring, control methods.	9
4	**Pollution Prevention Techniques**: Generic water management techniques. Pollution prevention in the electronic Industry, Power generation industry, Electroplating industry, Fabricated metals products industry. **Emerging Pollution:** Threats and Pollution Caused by Biotechnology and Nanotechnology. Application of biotechnology and nanotechnology in pollution Control. Threats and Pollution Caused by Renewable energy technologies (PV cells and batteries only included). **Case study**: Industrial pollution and disasters: Bhopal tragedy, Water pollution control and disposal of waste water in HPCL Refinery Vishakhapatnam.	9

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify sources and types of wastewater pollutants and selecting appropriate treatment methods, such as physical, chemical, and biological processes, to mitigate environmental impact effectively.	**K2**
CO2	Select suitable methods for treatment and disposal of sludge, solid waste.	**K2**
CO3	Evaluate and analyse devices for particulate contaminant control, and controlling gaseous contaminant	**K2**
CO4	Suggest pollution prevention techniques across various industries and explain the emerging threats and applications of biotechnology, nanotechnology, and renewable energy technologies in pollution control.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					3	3	3				3
CO2	3					3	3	1				3
CO3	3					3	3	1				3
CO4	3					3	3	1				3
CO5	3					3	3	1				3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Engineering	Peavy, H.S., Rowe, D.R. and Tchobanoglous, G	McGraw-Hill	SeventhEdition
2	Environmental Pollution Control Engineering	Rao C.S.	New age International Pub.	SecondEdition 2006
3	Air Pollution	M. N. Rao & H.V.N.Rao	Tata McGraw-Hill.	First Edition 2017
4	Industrial Pollution Prevention Handbook	Harry M. Freeman	Mc Graw Hill Education	2014
5	Environmental Pollution and control in Chemical Process Industries	S. C. Bhatia	Khanna Publishers	Second Edition 2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Industrial Wastewater Treatment	A. D. Patwardhan	PHI Learning Pvt. Ltd	Second Edition
2	Environmental Engineering	N. N. Basak	McGraw Hill Education (India) Pvt. Ltd.	First Edition
3	Solid and Liquid Waste Management: Waste to Wealth	RajaramVasudevan, Siddiqui Faisal Zia, Agrawal Sanjeev, Khan Mohammad Emran	PHI	First Edition, 2016
4	Integrated Solid Waste Management	Bhide A.D. and Sundaresan, B.B	CRC Press	First Edition
5	Fundamentals of Air Pollution	Boubel, R.W., Fox, D.L., Turner, D.B., Stern, A.C	Academic Press	Third Edition
6	Industrial Water Pollution Control	Eckenfelder W.W	Mc Graw hill EXCLUSIVE (CBS)	Third Edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/103107084 https://nptel.ac.in/courses/105106119
2	https://archive.nptel.ac.in/courses/103/107/103107215/ https://archive.nptel.ac.in/courses/105/105/105105160/
3	https://archive.nptel.ac.in/courses/105/107/105107213/
4	https://archive.nptel.ac.in/courses/127/105/127105018/

SEMESTER S6

ENERGY ENGINEERING AND MANAGEMENT

Course Code	**OEBBT614**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. The course makes the students understand the importance of energy conservation and the different methods employed for methods for harnessing different energy resources.
2. Students may gain knowledge on Energy Auditing, Energy conservation, Waste Heat Recovery, Maintenance of Energy Systems,

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Energy Conversion -** Energy resources, Global and Indian scenario of energy resources and consumption, Impact of Energy on economy, Energy policies, development and environment. **Conventional Energy conversion plants** –Thermal, Hydro, and Nuclear power plants, Comparison, advantages and disadvantages, Combined cycle power plants, **Energy from Hydrogen**:- Hydrogen as a source of energy, Sources, hydrogen energy storage and transportation, Applications, Future perspectives.	**9**
2	**Solar energy**- Solar thermal systems- Flat plate collectors- Focusing collectors- Applications of solar energy in India **Ocean energy**:- wave energy conversion, Ocean thermal energy conversion, Tidal energy conversion. **Wind energy**- Types of windmills- Wind electric power generation- Wind power in India, Magneto hydrodynamics, Fuel cells: types , working of	**10**

	PEMFC.	
3	**Energy management and Energy audit** **Energy Management** – Definitions and significance, Objectives, Characterizing of energy usage, Energy Management program, Energy strategies and energy planning. **Energy Audit** – Types, Procedure and Techniques, understanding energy costs, Benchmarking, Energy performance Optimum performance of existing facilities.	**8**
4	**Energy conservation** – Principles, Cogeneration, Waste heat recovery, Waste to Energy Technologies- Gasification, Pyrolysis, Fermentation, Anaerobic digestion: compressed biogas. **Energy Conservation Opportunities** – Electrical ECOs, hermodynamic ECOs in chemical process industry, ECOs in residential and commercial buildings, Energy Conservation Measures.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify energy resources and energy conversion processes.	**K2**
CO2	Explain energy conversion from solar, ocean , wind and fuel cells	**K2**
CO3	Explain and analyze energy management and energy audit procedures and techniques	**K3**
CO4	Identify energy conservation opportunities and apply energy conservation methods in various fields	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2					3	2					
CO2	2					3	2					
CO3	2					3	2	2				
CO4	2					3	2	2				

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Energy Technology	Rao S. & Parulekar B.B	Khanna Publishers	3rd Edn, 1994
2	Renewable Energy Sources & Conversion Tech	Bansal N.K., Kleeman M. & Meliss M	Tata McGraw Hill	1990
3	Energy for Sustainable Development	Md Hasanuzzaman, Nasrudin Abd Rahim (Eds)	Elsevier	2020
4	Energy Engineering and Management	Amlan Chakrabarti	Prentice Hall India	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Non-Conventional Energy Systems .	Mittal K.M.	Wheeler Publications	
2	Chemical Technology	Venkataswarlu D.I	S. Chand	
3	A Text Book on Energy System and Engineering	Pandey G.N.	Vikas Publishing	
4	Handbook of Energy Audits,	Albert Thumann P. E. and W. J. Younger	Fairmont Press	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/107/103107157/
2	https://archive.nptel.ac.in/courses/103/107/103107157/
3	https://archive.nptel.ac.in/courses/103/107/103107157/
4	https://archive.nptel.ac.in/courses/103/107/103107157/

SEMESTER S6

BIOINFORMATICS TECHNIQUES AND APPLICATIONS

Course Code	**OEBBT615**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge on Molecular Biology and Cell Biology	**Course Type**	Theory

Course Objectives:

1. To launch the Bioinformatics core concepts to students.
2. To provide knowledge on biological databases, sequence analysis, evolutionary analysis and applications of Bioinformatics.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Bioinformatics and Biological Databases Introduction to Bioinformatics: definitions, historical overview, applications and scope, Biology to understand the Bioinformatics – Important Biological Databases: Retrieving and analyzing data from biological databases, Genbank, NCBI, DDBJ, Pubmed, UniProt, PROSITE, SCOP, RCSB-PDB, EMBL-EB	9
2	Sequence Alignment and Phylogenetics Analysis Sequence alignment tools and algorithms: Substitution matrices, PAM, BLOSUM, Gap penalties, pairwise sequence alignment using Dynamic Needleman-Wunsch, Smith-Waterman, and Heuristic programming algorithms, FASTA and BLAST-Multiple sequence alignments: Common multiple alignment methods, CLUSTALX, identification of motifs and patterns, Hidden Markov model-Phylogenetic Analysis: Elements of phylogenetic models, Determining the substitution model tree, Evaluating phylogenetic trees	9
3	Structure Prediction and Analysis Predictive methods, Codon bias detection, Modular nature of proteins - Protein identity based on the primary, secondary, and tertiary structure of proteins, protein homology modeling,	9

	Bioinformatics approaches for Molecular modeling in drug discovery, Protein-Protein interactions	
4	Data Analysis and Interpretation High throughput sequencing and data analysis: Human Genome Project, Next generation sequencing, Detection of SNPs and their relevance, Detection of functional sites in the DNA sequences, Gene predictions, Microarray data analysis, Gene expression analysis	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Utilize the available online biological databases to retrieve and analyze sequences.	**K2**
CO2	Analyze the basic algorithms for sequence analysis of proteins and nucleic acids.	**K4**
CO3	Develop an idea about the predictive methods for the structure and function of any given nucleic acid and protein sequences based on sequence homology.	**K5**
CO4	Apply bioinformatics approaches to solve biological problems, such as gene annotation, molecular evolution, and drug designing.	**K3**
CO5	Critically evaluate the results of bioinformatics analyses and their biological significance	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	2	3	3	3	3	1	1	2	3
CO2	3	3	2	2	3	3	3	1	1	2	2	3
CO3	3	3	2	2	3	3	3	1	1	2	2	3
CO4	3	3	2	2	3	3	3	1	1	2	2	3
CO5	3	3	2	2	3	3	3	1	1	2	2	3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Bioinformatics	Arthur K. Lesk	5th Edn., Oxford University Press, 2019	2019
2	Bioinformatics and Functional Genomics	J. Pevsner	3rd Edn., Wiley-Blackwell, 2015	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Comparative Gene Finding: Models, Algorithms and Implementation	M. Axelson-Fisk,	. 2ndEdn, Germany: Springer London, 2015.	2015
2	Bioinformatics: Sequence and Genome analysis	D.W.Mount,	2nd Edn., Cold Spring Harbor Laboratory Press, 2004	2004
3	Statistical Analysis of Next Generation Sequencing Data.	S. Datta, D. Nettleton	Springer International Publishing, 1st Edn, 2014	2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt06/preview

SEMESTER S6

HYDROGEN ENERGY: PRODUCTION, STORAGE, TRANSPORTATION AND SAFETY

Course Code	**OEBBT616**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	Theory

Course Objectives:

1. This course provides a comprehensive knowledge of hydrogen production, storage and transportation, utilization in various sectors, associated energy conversion devices, sensing and safety.
2. The course will provide a broad knowledge of hydrogen as an energy carrier.
3. The course also covers the classification and working of fuel cells.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Hydrogen energy:** Hydrogen Economy- Decarbonisation of the Economy, road to the Hydrogen Economy. Properties of hydrogen as fuel. General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and hydrogen production plants.	**9**
2	**Hydrogen production pathways:** Thermal process-Steam reformation, Advanced Methods of Steam Reforming, Partial Oxidation Method for Hydrogen Production. Electrochemical- Electrolysis, photo electro chemical method. Thermo- chemical water splitting. Biological process: hydrogen production from microbial biomass conversion- gasification, pyrolysis.	**9**
3	**Hydrogen storage, safety and transportation:** Physical and chemical properties, general storage methods, compressedstorage-composite cylinders, metal hydride storage, carbon-based materials forhydrogen storage.	**9**

	Hydrogen safety aspects, backfire, pre-ignition, hydrogenemission NOx control techniques and strategies, Hydrogen Transportation via Hydrogen Pipelines, Long Distance Hydrogen Transmission, transportation via road, ships and in form of Liquid Organic Hydrogen Carriers (LOHC), hydrogen transported as ammonia, liquefied hydrogen (LH2) transportation, Hydrogen Refuelling Stations.	
4	**Hydrogen usage:** Overview of fuel cells, Alkaline fuel cells, Proton exchange membrane fuel cells, Methanol fuel cells, Phosphoric acid fuel cells, Molten carbonate fuel cells, Solid oxide fuel cells, Fuel cell comparison, Hydrogen combustion engines, Hydrogen turbines, Hydrogen gas burner, Gas engine combined heat and power plants.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Summarize the importance of hydrogen economy.	**K2**
CO2	Explain different methods of hydrogen production.	**K2**
CO3	Describe different techniques of hydrogen storage, transportation and various safety challenges in hydrogen storage.	**K2**
CO4	Explain the various uses of hydrogen energy.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1				2						2
CO2	2	1				2						2
CO3	2	1				2						2
CO4	2	1				2						2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Hydrogen Production by Electrolysis	AgataGodula-Jopek	Wiley-VCH, Germany	2015
2	Hydrogen Fuel: Production, Transport and Storage	Gupta, R. B.	CRC Press, Taylor & Francis Group.	2009
3	Fuel Cell Handbook	EG & G Technical Services,	Morgantown, West Virginia, USA	2004
4	Tomorrow's Energy: Hydrogen, Fuel cells and the prospects for a cleaner planet	Peter Hoffman	MIT Press, Cambridge, London, England	2001
5	Hydrogen storage: state-of-the-art and future perspective. Netherlands	Tzimas, E., Filiou, C., Peteves, S.D., &Veyret, J.B.	European Communities.	2003
6	Principles of Fuel Cells	Xianguo Li	Taylor & Francis.	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Hydrogen Storage	Michael Hirscher	Wiley-VCH 2.	2010
2	Electrochemical Methods	A.J. Bard and L.R.Faulkner	John Wiley & Sons, Inc.	
3	Introduction to Fuel Cell Technology	Chris Rayment and Scott Sherwin	Notre Dame, U.S.A.	2003
4	Fuel Cells: From Fundamentals to Applications	S Srinivasan	Springer	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL :: Chemical Engineering - NOC:Hydrogen Energy: Production, Storage, Transportation and Safety
2	NPTEL :: Chemical Engineering - NOC:Hydrogen Energy: Production, Storage, Transportation and Safety
3	NPTEL :: Chemical Engineering - NOC:Hydrogen Energy: Production, Storage, Transportation and Safety
4	NPTEL :: Chemical Engineering - Fuel Cell Technology

SEMESTER S6

ENVIRONMENTAL IMPACT ASSESSMENT

Course Code	**OEBBT617**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

Course Objectives:

1. To study the various types of environmental pollution
2. To study the impact of various types of pollutants and their assessment techniques

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** Legislations, laws and acts relevant to Environmental protection in India -The environment (protection) Act-1986, The Air (prevention and control of pollution) Act 1981, The Water (prevention and control of pollution) Act-1974, National environmental policy 2006. **Classification of Pollution and Pollutants-** **Water pollution:** Major Pollutants of Water and their effects, Physical, chemical and biological characteristics of water, Water Quality standards **Air Pollution:** Primary and Secondary Pollutants, Impact of air pollutants on human, vegetation and environment, Ambient Air Quality Standards, meteorological factors affecting air pollution.	**11**
2	**Solid waste:** Classification and sources of Solid Waste, Characteristics of Solid Waste. **Land Pollution:** Effects of urbanization on land degradation, Impact of Modern Agriculture on Soil, pesticide pollution, Effect on Environment. Noise Pollution: Sources of Noise, Effects of Noise, measurement of noise, Equivalent sound pressure level, Control measures. Environmental impact assessment, Need for EIA	**11**
3	Screening –scoping - setting – analysis – mitigation, Impact identification and prediction: Matrices – Networks – Checklists –Cost benefit analysis,	**13**

	Analysis of alternatives, Description of the affected environment – environmental indices, Short EIA and comprehensive EIA, Case studies of EIA, Impact analysis	
4	EIA Report preparation, Environmental Management Plan - preparation, Implementation and review – Mitigation and Rehabilitation Plans, Public Consultation, Post Monitoring and Auditing	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	study the environmental legislation in India and to understand various types of environmental pollutants affecting air and water	**K1**
CO2	Understand the effects of solid waste and noise pollution on the environment.	**K1**
CO3	Describe the steps involved in EIA and to study how to conduct impact analysis of various pollutants.	**K2**
CO4	Develop EIA report and to document EIA and to conduct environmental auditing.	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					3	3					
CO2	3					3	3					
CO3	3	3				3	3					
CO4	3	3			2	3	3					

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Impact Assessment	Canter, L.W	McGraw Hill, New York	1996

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Engineering	Peavy H S, Rowe, D.R. Tchobanaglous	Mc Graw Hill Education	
2	Air Pollution	Rao M.N. & Rao H.	Tata McGraw-Hill	
3	Environmental Impact Assessment – Practical solutions to recurrent problems	Lawrence, D.P.	Wiley-Interscience	2003
4	Environmental Impact Assessment: A Practical Guide	Marriot, Betty	Mc Graw Hill Education	1997
5	Source book on EIA		World Bank	
6	Environmental Pollution Control Engineering	C S Rao	New Age International Publishers	4^{th} edition

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	http://tjsec.digimat.in/nptel/courses/video/124107160/L57.html
2	
3	
4	

SEMESTER S6

REACTION ENGINEERING AND PROCESS CONTROL LAB

Course Code	**PCBBL607**	**CIE Marks**	50
Teaching Hours/Week (L: T:P: R)	0:0:3:0	**ESE Marks**	50
Credits	2	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	PBBBT404 & PCBBT601	**Course Type**	Lab

Course objectives:

1. To develop practical skills in chemical reaction engineering and process control by applying fundamental principles of chemical reaction engineering and process control.
2. To equip students with the skills to design experiments, collect and analyze data using modern computing tools.
3. To foster ethical and collaborative laboratory practices.

Experiment No.	**Syllabus**
	PART A
1	Kinetic studies in an isothermal batch reactor
2	Kinetic studies in an isothermal semi-batch reactor
3	Kinetic studies in a continuous stirred tank reactor
4	Kinetic in an isothermal tubular reactor
5	Kinetic in a plug flow reactor
6	Kinetic studies in a packed bed reactor
7	RTD studies in CSTR
8	RTD studies in PFR
9	Determination of activation energy in an isothermal batch reactor
10	Determination of activation energy in an isothermal semi-batch reactor
	PART B
11	Study of dynamic response in a single tank level control system
12	Study of dynamic response in two tanks non-interacting level control system
13	Study of dynamic response in two tanks interacting level control system
14	Study of pneumatic valve characteristics
15	Dynamic response of industrial thermometer with well
16	Dynamic response of industrial thermometer without well
17	Dynamic response of a U tube manometer
18	Temperature Control Trainer
19	PID controller trainer
20	Effect of the tuning parameters in the response of a process control system

Note: A minimum of 10 experiments must be conducted by suitably designing 5 experiments from Part A and 5 experiments from Part B

Course Assessment Method
(CIE: 50 marks, ESE: 50 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)	Internal Examination	Total
5	25	20	50

End Semester Examination Marks (ESE):

Procedure/ Preparatory work/Design/ Algorithm	Conduct of experiment/ Execution of work/ troubleshooting/ Programming	Result with valid inference/ Quality of Output	Viva voce	Record	Total
10	15	10	10	5	50

- ***Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.***
- ***Endorsement by External Examiner:*** *The external examiner shall endorse the record*

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Use the basic principles of Chemical Reaction Engineering and Process Control to find kinetics of Chemical reaction and responses of process control systems by performing experiments	K3
CO2	Design experiments and interpret data collected from experimental investigations	K3
CO3	Use modern computing tools necessary for analysis of the experimental data	K3
CO4	Practice ethical approaches in experimental investigation, collection and reporting of data and adhering to the safety ethics set by the laboratory.	K3
CO5	Practice work in diverse groups and perform laboratory experiments.	K3
CO6	Communicate through oral and writing skills through viva and preparing reports of experimental work.	K3

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2										2	
CO2		2		2								2
CO3					2							
CO4								2				
CO5									2			
CO6										2		

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Chemical Reaction Engineering	Octave Levenspiel	Wiley Student Edition	Third, 2021
2	Process Systems Analysis and Control	Coughanowr R D, LeBlanc E S,	McGraw Hill International Edition	Third Edition

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Essentials of Chemical Reaction Engineering	H Scott Fogler	Pearson Education	Second, 2020
2	Chemical Process Control: An Introduction to Theory and Practice	Stephanopoulose G	Pearson Education India Edition	First Edition

Continuous Assessment (25 Marks)

1. **Preparation and Pre-Lab Work (5 Marks)**
   - Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
   - Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.
2. **Conduct of Experiments (5 Marks)**
   - Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
   - Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.

- Teamwork: Collaboration and participation in group experiments.

3. **Calculation, Plotting of Graph and use of modern tools (5 Marks)**
   - Data Analysis: Accuracy and completeness in calculations, including error analysis and statistical evaluation.
   - Graphical Representation: Ability to create clear and accurate graphs, charts, and plots to represent experimental data and use of appropriate tools to enhance the visualization and interpretation of data.
   - Proficiency in using software tools: Effective use of modern computing tools such as MATLAB, MS- Excel, or other relevant tools for simulation, modeling, and analysis related to the experiments. Integration of software tools with experimental data to draw meaningful conclusions
   - Numerical Methods: Application of suitable numerical methods for curve fitting, interpolation, or other relevant analyses.
4. **Lab Reports and Record Keeping (5 Marks)**
   - Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of
   - experiments, data analysis and conclusions.
   - Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.
5. **Viva Voce (5 Marks)**
   - Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

Final Marks Averaging: The final marks for preparation, conduct of experiments, Calculation and use of modern tools viva, and record are the average of all the specified experiments in the syllabus.

Evaluation Pattern for End Semester Examination (50 Marks)

1. **Procedure/Preliminary Work/Design/Algorithm (10 Marks)**
   - Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
   - Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
   - Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
   - Creativity and logic in algorithm or experimental design.

2. **Conduct of Experiment/Execution of Work/Programming (15 Marks)**
    - Setup and Execution: Proper setup and accurate execution of the experiment or programming task.
3. **Result with Valid Inference/Quality of Output (10 Marks)**
    - Accuracy of Results: Precision and correctness of the obtained results.
    - Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.
4. **Viva Voce (10 Marks)**
    - Ability to explain the experiment, procedure results and answer related questions
    - Proficiency in answering questions related to theoretical and practical aspects of the subject.
5. **Record (5 Marks)**
    - Completeness, clarity, and accuracy of the lab record submitted

SEMESTER 7

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

Common for
BIOTECHNOLOGY ENGINEERING

SEMESTER S7

SYNTHETIC BIOLOGY

Course Code	**PEBBT741**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	none	**Course Type**	Theory

Course Objectives:

1. This course would enable students to design and construct new biological parts, devices, and systems, and re-design the existing, natural biological systems for useful purposes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**New tools for cost-effective DNA synthesis** Oligonucleotide synthesis: Column oligonucleotide synthesis, Microarray Oligonucleotide Pool Synthesis, Microfluidic and Fluidic Systems, Photolithography, Electrochemical Arrays, Inkjet Printing. Gene assembly, Applications of DNA synthesis: Gene circuits, codon optimization, and Genome synthesis	**9**
2	**Proteins as a tool for synthetic biology** Protein engineering methods: Directed evolution, Generating sequence diversity: Random mutagenesis, Recombination, Site-directed Diversification. Screening and selection of protein: High-throughput screening in microtiter plates, Flow cytometry, Phage display, Cell-Free ribosome, and mRNA display, Auxotrophic complementation. Application of protein engineering in synthetic biology.	**9**
3	**From Biological Parts to Circuit Design** The parts are transcription, Translation, and Degradation. Assembling parts, Circuit design: Semirational Directed evolution, Design of experiment approaches	**9**

4	**Design and application of synthetic biology** Target organisms and cell types for therapeutic applications of synthetic biology: Synthetic Gene Circuits encoded by recombinant DNA, Types of synthetic gene circuits: Genetic Switches, Oscillators, filters, communication modules, Functional proteins and RNA components of synthetic gene circuits, Induction of synthetic gene circuits, Alternatives to Recombinant DNA: Synthetic/Modified RNA, Proteins, and Other Analogue Molecules, Therapeutic applications of synthetic biology	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the new tools for cost-effective DNA synthesis	**K2**
CO2	Recall the usage of proteins in the field of synthetic biology	**K1**
CO3	Evaluate experimental planning from biological parts to circuit design	**K5**
CO4	Comprehend and address the design and application of synthetic biology	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										3
CO2	3	2										3
CO3	3	2	3									3
CO4	3	2										3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Regenesis: how synthetic biology will Reinvent nature and ourselves.	G. George, E. Regis	. 1st Edn.,Perseus Book Press, 2014	**2014**
2	Synthetic biology: A primer.	G Baldwin, T Bayer, R Dickinson, T Ellis, P. S Freemont, R.I. Kitney, K. M. Polizzi, G.B. Stan	1st Edn., Imperial College Press. 2016.	**2016**

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Synthetic Biology: Tools and Applications	H. Zhao	1st Edition, Academic Press, 2013	**2013**
2	Synthetic Biology: Parts, Devices and Applications	C. Smolke	Vol 8, Wiley, 2018	**2018**

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL :: Biotechnology - NOC:Computational Systems Biology
2	
3	
4	

SEMESTER S7

CELL SIGNALING

Course Code	PEBBT742	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Basics of cell biology	Course Type	Theory

Course Objectives:

1. To understand the process of cell signalling in normal physiological process
2. To understand the basic principles of signal transduction mechanisms
3. To study the different extracellular signals and receptors and their functional significance

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Protein targeting and membrane trafficking. Cytoskeletal organization and dynamics. Cell adhesion and extracellular matrix, Cell division cycle, Cell cycle and death	8
2	Two-component system (TCS) in procaryotes, Evolution and TCS in eukaryotes. Basic principles of cell signaling. Characterization of signaling components: signaling molecules, receptors, second messengers, effectors, signaling complexes. Integration and amplification of signals. Basic classification and characterization of membrane receptors.	9
3	Introduction to G Protein Coupled Receptor (GPCR) Signaling. Growth Factor/ Receptor Tyrosine Kinases (RTKs) and Wnt Receptors. Ras to Mitogen-Activated Protein Kinase (MAPK) Pathways. Protein Kinases. Protein Phosphatases. Domains in RTKs: Structural Aspects. Ligand-Gated Channels, Regulation of Ion Channels by G Proteins, Transient Receptor Protein (TRP) Channels	10

4	Nuclear Transactivators and Repressors, Chromatin Remodeling, Nuclear Receptors Cell cycle control. Signaling defects. Examples of physiological roles (apoptosis, cell cycle regulation, gene transcription) and clinical significance (cancer, cardiovascular disease, learning and memory, immune responses).	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the components, principles and properties of major cell signalling pathways.	**K2**
CO2	Describe how cells exploit signalling components to assemble the specific signalling pathways, which they require to communicate which each other or to adapt to changes of external environment.	**K2**
CO3	Justify the role of signalling pathways in control of gene expression (transcription and translation) and cellular metabolism.	**K5**
CO4	Identify the clinical Significance of Cell signalling	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2			2						2		2
CO2	2									2		2
CO3		3		2						2		2
CO4		3		2				3		2		2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cell Biology	Rastogi	New Age international Publishers	2015
2	Textbook of Cell Signaling in Cancer	Jacques Robert	Springer	2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Molecular and Cellular Signaling	Martin Beckerman	Springer	2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/102/106/102106025/

SEMESTER S7

COMPUTATIONAL BIOLOGY

Course Code	PEBBT743	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	2-0-1-0	ESE Marks	60
Credits	3	Exam Hours	2.30
Prerequisites (if any)	Basic Knowledge of Bioinformatics	Course Type	Theory

Course Objectives:

This course will enable students to

1. Utilize network-based methods to model biological systems and analyze biological networks.
2. Critically assess and apply recent research papers and developments in the field of AI-driven computational biolog

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Electronic Structure Methods** Quantum chemical methods are semi-empirical and ab initio methods. Conformational analysis, energy minimization, and predicting the mechanism of organic reactions using electronic structure methods.	**8**
2	**Molecular Modeling** Bioactive vs. global minimum conformations. Automated methods of conformational search. Advantages and limitations of available software. Molecular graphics. Computer methodologies behind molecular modeling including artificial intelligence methods.	**8**
3	**Structure-Activity Relationships In Drug Design** Qualitative versus quantitative approaches advantages and disadvantages. Random screening, Non-random screening, rational approaches to lead discovery. Homologation, chain branching, ring-chain transformations. Insights into molecular recognition phenomenon. Structure-based drug design, ligand-based drug design.	**8**

4	**QSAR: Electronic Effects** Hammett equation, lipophilicity effects. Hansch equation, steric effects. Taft equation. Experimental and theoretical approaches for the determination of physicochemical parameters, parameter interdependence: Regression analysis, Descriptor calculation. The importance of biological data in the correct form; 2D QSAR; and 3D-QSAR examples of CoMFA and CoMSIA. **Molecular Docking** Rigid docking, flexible docking, manual docking. Advantages and disadvantages of Flex-X, FlexS, Autodock, and Dock software, with successful examples. Dynamics of drugs, biomolecules, drug-receptor complexes, Monte Carlo simulations, and Molecular dynamics in performing conformational search and docking.	**12**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop and apply algorithms for structural bioinformatics and healthcare.	**K6, K3**
CO2	Interpret and practice the fundamental concepts of Molecular Modeling and Computer-aided Drug Design	**K3**
CO3	Develop practical skills in computational approaches to analyze, predict, and engineer biomolecules and biomolecular systems	**K6, K5, K4, K3**
CO4	Find a chemical compound that can fit into a specific cavity on a protein target both geometrically and chemically.	**K3, K5**
CO5	Apply appropriate tools for such modeling, ranging from electronic Structure methods, Molecular modeling, Structure-Activity Relationships in drug design, QSAR, Molecular docking and Molecular dynamics and docking, modeling, and electronic structure methods which leads to new drug target design	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3			2							2
CO2	3	3	2	2	2				2			2
CO3	3	3	2	2	2	2			2			2
CO4	3	3	2	2	3	2			2			2
CO5	3	3	2		2				2			2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Understanding bioinformatics	Zvelebil, Marketa J., and Jeremy O. Baum	Garland Science	2007
2	Essential bioinformatics.	Xiong, Jin	Cambridge University Press	2006
3	Introduction to Bioinformatics	Teresa K. Attwood, David J Parry-Smith	Pearson Education	1999
4	Bioinformatics – A Practical Guide to the Analysis of Genes and Proteins	Baxevanis AD,Francis Ouellellette BF	Wiley Interscience	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Applied bioinformatics. An introduction	Selzer, Paul M., Richard J. Marhöfer, and Andreas Rohwer	Springer, Verlag	2008
2	Bioinformatics: Methods and Applications	S C Rastogi, N Mendiratta and PRastogi	PHI Learning Private Limited, New Delhi	2015
3	D E Krane and M L Raymer	Fundamental Concepts of Bioinformatics	Pearson Education	2006

SEMESTER S7

PATENTS AND IPR

Course Code	PEBBT744	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

The main objective of the IPR is to make the students

1. Aware of their rights for the protection of their invention done in their project work.
2. To get registration in our country and foreign countries for their invention, designs, and thesis or theory written by the students during their project work, they must know about patents, copyrights, trademarks, designs, and the Information Technology Act.
3. Further teacher will have to demonstrate with products and ask the students to identify the different types of IPRs.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to IPRs** Basic concepts and need for Intellectual Property - IPR in India and Abroad – Genesis and Development – the way from WTO to WIPO – TRIPS, Nature of Intellectual Property, Industrial Property, technological Research, Inventions, and Innovations – Important examples of IPR.	**10**
2	**Registration Of IPRs** Meaning and practical aspects of registration of Copyrights, Trademarks, Patents, Geographical Indications, Trade Secrets, and Industrial Design registration in India and Abroad	**8**

3	**Agreements And Legislations** International Treaties and Conventions on IPRs, TRIPS Agreement, PCT Agreement, Patent Act of India, Patent Amendment Act, Design Act, Trademark Act, Geographical Indication Act.	**9**
4	**Digital Products And Law** Digital Innovations and Developments as Knowledge Assets – IP Laws, Cyber Law and Digital Content Protection – Unfair Competition – Meaning and Relationship between Unfair Competition and IP Laws – Case Studies. **Enforcement of IPRs** Infringement of IPRs, Enforcement Measures, Emerging issues – Case Studies.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two question

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the process of acquiring the patent	**K2**
CO2	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology	**K2**
CO3	Apply copyright for innovative works.	**K3**
CO4	Understand plagiarism in innovations that can be questioned legally.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2				3		3				3
CO2	3	2				3		3		2		3
CO3	3	2				3		3				3
CO4	3	2				3		3				3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Managing Intellectual Property,	V. Scople Vinod,	Prentice Hall of India Pvt Ltd, 2012	2012
2	Intellectual Property Rights and Copyrights	S. V. Satakar,	Ess Ess Publications, New Delhi, 2002	2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets	Deborah E. Bouchoux	Cengage Learning, Third Edition, 2012.	2012
2	Intellectual Property Rights: Unleashing the Knowledge Economy.	Prabuddha Ganguli	McGraw Hill Education, 2011	2011
3	The Management of Intellectual Property,	Edited by Derek Bosworth and Elizabeth Webster	Edward Elgar Publishing Ltd., 2013	2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1, 2, 3 & 4	https://onlinecourses.nptel.ac.in/noc21_hs08/preview

SEMESTER S7

METABOLIC ENGINEERING

Course Code	**PEBBT746**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge in biochemistry, and cell biology	**Course Type**	Theory

Course Objectives:

1. To provide fundamental knowledge on the upcoming field of Metabolomics and metabolic engineering in the post-genomic era.
2. To introduce the redesign of metabolism to enable cells to produce new products

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Metabolic Engineering Introduction to metabolic engineering: Essence of Metabolic engineering, Basic concepts of metabolic engineering; Overview of Cellular metabolism, Cellular metabolism, Transport processes, Fueling reactions, Biosynthetic reactions, Polymerization, and Growth energetics.	9
2	Metabolic Flux Analysis Metabolic flux analysis, Methods for metabolic flux analysis, Application of metabolic flux analysis, Amino acid production by bacteria, Metabolic flux analysis for glutamic acid and lysine biosynthetic networks, Fluxes in mammalian cell cultures, Flux analysis and design of culture media.	9
3	Metabolic Control Analysis Metabolic control analysis (MCA), Control coefficient and elasticity, Summation and Connectivity theorems, Determination of Flux control coefficients, MCA of Linear Pathways and Branched Pathways,	9

4	Applications of Metabolic Engineering Introduction to Omics: Functional genomics, proteomics, metabolomics, systems biology; Application of metabolic engineering: Enhancement of product yield, Alteration of nitrogen metabolism, Production of antibiotics, vitamins, polyketides, etc., Bioconversions, Case studies from Research Articles	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Remember the fundamental concepts of metabolic engineering and its importance in manipulating cellular metabolism.	**K1**
CO2	Assess the metabolic pathways using metabolic flux analysis.	**K3**
CO3	Analyze the metabolic control using metabolic control analysis (MCA) and apply the MCA theorems.	**K4**
CO4	Evaluate the applications of metabolic engineering and omics technologies in biotechnology	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3										2
CO3	3	3										2
CO4	3	3										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Metabolic Engineering: Principles and Methodologies,	G. N. Stephanopoulos, A. A. Aristidou, and J. Nielson	Academic Press, 1998.	1998
2	Pathway Analysis and Optimization in Metabolic Engineering	N. V. Torres and E. O. Voit,	Reprint., Cambridge University Press, 2011	2011
3	Metabolic Engineering in the Post-Genomic Era	B. Kholodenko	New edition Edn., Taylor & Francis, 2004	2004

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Metabolic and Cellular Engineering.	Cortassa, S.	Singapore: World Scientific. 2012	2012
2	Metabolic Engineering. Germany: Springer. 2010	Jens Nielsen	Germany: Springer. 2010	2010

SEMESTER S7

HIGH RESOLUTION SEPARATIONS IN BIOTECHNOLOGY

Course Code	**PEBBT745**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge in Bioprocess Engineering	**Course Type**	Theory

Course Objectives:

1. This course will enable students to develop bioengineering skills for the production of biochemical product using integrated biochemical processes

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Affinity precipitation:** Various formats, heterobifunctional ligands, use of macro-affinity ligands, practical applications. **Membrane-based affinity separations:** Chemical and physical feature of membrane matrix, purification protocol, ligand coupling, stability of active membranes, ligand leaching, scale-up and applications.	9
2	**Affinity partitioning:** Two-phase systems, general ways of steering the partitioning, large scale extractions, non-protein partitioning, counter-current distribution. **Reverse micelles for protein bioseparations:** Microstructure and general properties of reverse micelles, reverse micellar extraction, mass transfer of protein extraction, process development, examples of applications for protein separation.	9
3	**Affinity chromatography:** Role of affinity chromatography in protein purification, affinity packings, characterization of packings, modelling and design of AC columns.	9

	Protein fusions for protein purification: Choice of host organism, induction of expression, solubilization of recombinant proteins, vectors, affinity purification, thrombin cleavage of fusion proteins.	
4	**Chiral separations:** Chirality and biological systems, methods for chiral separation- chromatographic methods, chiral detectors, non-chromatographic methods. **Molecular imprinting:** Preparation of molecular imprints, recognition in molecular imprinted polymers, applications- chromatography, analysis.	9

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the principles underlying various affinity separation methods in Biotechnology.	**K2**
CO2	Illustrate the design and engineering of various highly selective separation process systems.	**K3**
CO3	Outline salient features of chiral separations, protein fusions and molecular imprinting in the context of protein purification.	**K2**
CO4	Discuss the principles and applications of reverse micelle-based processes in bioseparations.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2	3	3	3	2								
CO3	3											
CO4	3											

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Highly Selective Separations in Biotechnology	G. Street	Springer	1st ed. 1994
2	Chromatography in Biotechnology	Csaba Horvath, Leslie E Ettre	American Chemical Society	1st ed. 1993
3	Membrane Separations in Biotechnology	William K Wang	CRC Press	2nd ed. 2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Separation, Recovery and Purification in Biotechnology: Recent Advances and Mathematical Modelling	Juan A Asenjo	American Chemical Society	1st ed. 1986
2	Separations Technology: Pharmaceutical and Biotechnology applications	Wayne. P. Olson	CRC Press	1st ed. 1995
3	Separation and Purification Techniques in Biotechnology	Frederick J Dechow	Noyes Publications	1st ed. 1989

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/103105061

SEMESTER S7

DEVELOPMENTAL BIOLOGY

Course Code	**PEBBT751**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Foundation in Molecular Biology and Cell Biology	**Course Type**	Theory

Course Objectives:

This course introduces the student to the molecular and cellular principles behind how a single cell becomes a multicellular organism with specialized tissues and organs. The students will learn

1. To ask the key questions in development
2. How cells communicate in promoting the development of a multicellular organism
3. How the body plan of a multicellular organism is patterned to give rise to specialized tissues and organs
4. To appreciate the conservation of the molecular and cellular principles across different species
5. To understand the influence of the external environment in the developmental process, and
6. To analyse and integrate the scientific data that are used to answer all these questions in development.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction: Basic concepts of Development** Potency of embryonic cells, Commitment, Specification (Autonomous and Conditional), Induction, eye lens induction, regional specificity of induction, Genetic specificity of induction, Polyspermy and prevention of polyspermy, Differentiation, Morphogenetic gradients, Cell fate and cell lineages. Activation of egg, Embryo Transfer (ET) and In Vitro Fertilization (IVF) in Humans and Livestock, superovulation and embryo culture	**9**

2	**Fertilization and Various Developmental aspects** Fertilization (External and Internal) Early Cleavage and Axis Formation, Gastrulation-Biochemical and Molecular aspects, Chemical changes associated with cleavage, Cell Surface Molecules in sperm - egg recognition. Early Embryonic Development, Gametogenesis, Spermatogenesis, Oogenesis and Types of egg, Egg Membranes. Metabolic events during gastrulation.	9
3	**Metamorphosis and Regeneration** Metamorphosis of Amphibians and Insects; Hormonal control of metamorphosis. Heterochrony-neoteny, progenesis (Brief accounts); regeneration - different types of regeneration; Histological processes during regeneration; Polarity and Metaplasia in regeneration; Lens regeneration in amphibia.	7
4	**Human Welfare and Developmental Biology.** Stem cells and their applications, ethical issues. Malformations and disruptions, Gene – phene relationship, Autophene, Allophene and Pleiotrophy; Environmental oestrogens. animal welfare: Bioethics, Environmental ethics and Government ethics. Animal protection: Laws and Rules; IAEC – Rules and Regulation. Ethics on cloning and stem cell research. CPCSEA Guidelines for Laboratory Animal Facility, Veterinary care, Animal procurement, Quarantine, Sterilization and separation, Surveillance, diagnosis, treatment and control of disease	10

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the mechanisms animal embryos employ to generate patterns and complexity	**K2**
CO2	Understand the physical and biological basis for pattern and complexity	**K2**
CO3	Identify common developmental mechanisms across different genres of animals and in different developing tissues	**K2**
CO4	Extrapolate to generate hypotheses on how an unknown tissue may develop	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3	-	-	-	-	-	-	-	-	-	2
CO2	1	3	1	-	-	-	-	-	-	-	-	2
CO3	2	3	2	-	-	-	-	-	-	-	-	2
CO4	3	2	-	3	-	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	An Introduction to Embryology	Balinsky, B.I	W.B.SaundersCo.,Philadelphia	2004
2	Developmental Biology (11thedn	Gilbert, S.F	Sinauer Associates Inc., Publishers, Masachusettes,	2016
3	Principles of Development. (4thedn	Wolpert L. and C. Tickle	Oxford University Press, Oxford.	2011
4	Developmental Biology, a Modern Synthesis	Vasudeva Rao, K	Oxford-IBH, New Delhi 15	1994
5	Bioethics	Oxford-IBH, New Delhi 15	Published by Wisdom Educational Service, Chennai.	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Development	Lewis Wolpert	Oxford University Press.	2007
2	Developmental Biology- Patterns, Principles and Problems	Oxford Saunders, J.W.	Macmillan Publishing Co, New York	1982
3	Principles of Development, 2nd Edn,	Wolpert, L., Beddington, R., Jessel, T., Lawrence, P., Meyerowitz, E. and Smith, J.	Current Biology, Oxford	2002

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt43/preview
2	
3	
4	

SEMESTER S7

NEUROBIOLOGY

Course Code	**PEBBT752**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Foundation in Molecular biology and Cell biology	**Course Type**	Theory

Course Objectives:

At the end of the course, students should be able to

1. Define the molecular, cellular, and tissue-level organization of the central and peripheral
2. nervous system. Relate the properties of individual cells to their function in organized neural circuits and systems
3. Outline the properties of cells that make up the nervous system including the propagation of
4. electrical signals used for cellular communication
5. Restate the basics of neural pathology and pathogenesis.
6. Identify the basic concepts of the mind and brain that define the discipline of cognitive science.
7. Formulate a research question and design an original research plan to address an original research question

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction:** History, cytology of neurons, synthesis, and trafficking of neuronal protein, sensation and perception, cognition and behavior, anatomical organization of the central nervous system **The Neural Basis of Cognition** Functional organization of perception and movement, integration of sensory and motor function, Coding of sensory information, bodily senses, touch, perception of pain, visual processing, perception of motion, depth and form,	**9**

	sensory transduction in the ear, chemical senses (smell and taste)	
2	**Synaptic Transmission** Signaling at the nerve-muscle synapse, synaptic integration, modulation of synaptic transmission, transmitter release, neurotransmitters, synaptogenesis, myasthenia gravis. **Electrical Properties of Neuron** Subtypes of Ion Channels, membrane potential, local signaling, action potential	**9**
3	**Development of the Nervous System** Induction and patterning of the nervous system, generation, and survival of nerve cells, guidance **Arousal, Emotion, and Behaviour Homeostasis** Brain stem modulation of sensation, movement and consciousness, seizures and epilepsy, sleep and dreaming, emotional states and feelings, motivational and addictive states	**7**
4	**Diseases of the Nervous System** Neurobiology of affective disorders or mood disorders; dopamine and addiction; current research on Alzheimer's disease, Parkinson's disease, Huntington's disease, autism spectrum disorders (ASD), Depression, Anxiety, multiple sclerosis, and Japanese encephalitis. Methods in Neurobiology: Single neuron recording, intracellular recording, extracellular recording, ECG, EEG, lesion and stimulation of the brain, MRI, fMRI, PET, CAT, Morris water maze assay **Contemporary issues:** Lecture by Industrial Expert	**11**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the basic concepts about the organization, structure, and function of the human central nervous system\	**K2**
CO2	Apply these fundamental principles of molecular biology and cell signaling toward solving nervous system dysfunction	**K3**
CO3	Apply clinical problem-solving concerning disorders that affect the nervous system, with emphasis on the central nervous system	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3	2									2
CO3	3	3	2									2

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Principles of Neural Science.	Kandel E.R., Schwartz J.H. and Jessell T.M.	McGraw Hill 2015	2015
2	Molecular and Cellular Physiology of Neurons	Fain G.L	Harvard University Press	2005

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	APA. DSM-IV: Diagnostic and Statistical Manual of Mental Dis- orders. Washington, DC:		American Psychological Association	2013
2	Adult Neurogenesis.	Gage, Kempermann and Song	Cold Spring Harbor Laboratory Press	2008
3	Neurotransmitters, Drugs and brain functions	R A Webster	Harvard University Press	2002

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
1	https://onlinecourses.nptel.ac.in/noc23_bt65/previewhttps://onlinecourses.nptel.ac.in/noc23_ge32/preview https://onlinecourses.nptel.ac.in/noc20_ee95/preview
2	
3	
4	

SEMESTER S7

CELL CULTURE TECHNIQUES

Course Code	**PEBBT753**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Foundation in Micro Biology and Cell Biology	**Course Type**	Theory

Course Objectives:

1. This course will be a short primer for the students to understand how animal cell culture technologies have strengthened the bio-medical research from basic research to the modern drug discovery.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Cell Culture Laboratory Design And Equipment:** Planning, construction and services; Layout; Sterile handling area; Incubation; Hot room; Air circulation; Service bench; Laminar flow; Sterilizer; Incubators; CO2 incubator; Culture Racks, Colony Counters, Refrigerators and freezers; Centrifuge; Inverted stage microscope; Magnetic stirrer; Liquid nitrogen freezers; Slow cooling system for cell freezing; Water bath; Autoclaves and hot air oven; Pipette washers; Water purification system; Fluid handling systems and other equipments; Washing, packing and sterilization of different materials used in plants, animals and microbial cell cultures; Aseptic concepts; Maintenance of sterility; Cell culture vessels	9
2	**Media And Reagents:** Types of cell culture media for plants, animals and microbial cells; Ingredients of media; Physiochemical properties; Buffers; Oxygen; Osmolarity; Temperature; Balance salt solutions; Antibiotics, growth supplements; Conditioned media; Other cell culture reagents; Preparation	9

	and sterilization of cell culture media and other reagents.	
3	**Animal Cell Cultures Techniques:** History of animal cell culture; Different tissue culture techniques; Cell separation, disaggregation of the explants, mechanical and enzymatic disaggregation; Continuous cell lines; Organ culture, techniques, advantages, disadvantages, applications; Cell cultures, substrate culture and suspension culture; Primary cell culture; Secondary cell culture (cell lines); Development, characterization and maintenance of cell lines, Cryopreservation; Commercial scale production of animal cells; stem cells-fate mapping, application; Application of animal cell culture for in vitro testing of drugs;	**7**
4	**Plant Cell Culture Techniques:** Cellular Totipotency, And its Applications. Organogenesis, factors affecting organogenesis. Cytodifferentiation. Somatic Embryogenesis, Synthetic Seeds, Techniques for production of haploids, diploidization, production of double haploids and their Applications. Triploids production - Endosperm culture and Applications. Secondary metabolite production, selection of high yielding lines, elicitation, immobilization of cultures, hairy root culture and biotransformation. Factors affecting secondary metabolites, industrial application of secondary metabolites. Molecular farming. **Microbial Cell Culture Techniques:** Auxotroph isolation - replica plating technique, Screening Preservation of microbial products. Production of antibiotics. Enumeration and screening of novel microbial secondary metabolites, strain improvement, Use of microbes in industrial waste treatment. Microbial leaching.	**11**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the various sources of cells to be used in cell culture techniques	**K2**
CO2	Correlate between different biological samples and understand the importance of different media in tissue culture	**K2**
CO3	Comprehend the applications of plant, animal and microbial cell culture in industry, healthcare and environment	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										2
CO2	3	3										2
CO3	2	3										2

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Plant Cell Culture: A Practical Approach	R.A. Dixon & Gonzales	IRL Press 1994	1994
2	Culture of animal cells-A manual of basic technique and specialized applications	R. Ian Freshney	Wiley Blackwell publishers 1983	1983
3	Microbial Biotechnology	Alexander N Glazer, Hiroshi Nikaido W H	Freeman & Company 1995	1995

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Living resources for Biotechnology, Animal cells	Doyle, R. Hay and B.E. Kirsop	Cambridge University Press 1990	1990
2	Plant Tissue Culture	Sathyanarayana B N,	IK Intl. Publishers 2007	2007

Video Links (NPTEL, SWAYAM…)

Module No.	Link ID
1	https://archive.nptel.ac.in/noc/courses/noc21/SEM2/noc21-bt47/
2	
3	
4	

SEMESTER S7

BIOREMEDIATION

Course Code	PEBBT754	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	2:1:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 min.
Prerequisites (if any)	nil	Course Type	Theory

Course Objectives:

1. To introduce the microbiological and engineering fundamentals of bioremediation for treating municipal, agricultural, and industrial contaminants.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to bioremediation**, Historical development of environmental bioremediation, Requirements for bioremediation, Constraints and priorities of bioremediation, Factors affecting bioremediation Bioremediation; Societal and legal background **Biodegradation-** principles and microbiology; Limitations of bioremediation Overall view on in situ and ex-situ bioremediation techniques. Advantages and disadvantages	**9**
2	**Bioremediation strategies** – biostimulation and bioaugmentation, Biosorption, and precipitation. Biodegradation kinetics, Bioavailability, Biomineralization, Testing for biodegradability **Microbes for bioremediation:** Essential characteristics of microbes for Bioremediation - Microbial adaptation for adverse conditions - Metabolic process involved in bioremediation. **Advantages and disadvantages of specific bioremediation**	**9**

	technologies - Land farming - Prepared beds - Biopiles, composting, constructed wetlands,	
3	**Bioremediation of Soil and water** contaminated with oil and pesticides- Effects of Cosubstrates on microorganisms – Rhizo remediation- applications' **Gaseous bioremediation,** bio-scrubbers, bioventing, Soil Vapour Extraction (SVE), Water recirculation systems, Air sparging, Biobarriers, **Bioremediation technologies for heavy metal and radionuclides removal:** Microbial transformation - Accumulation and concentration of metal, Microbial interactions with heavy metals - resistance &tolerance -Biosorption of heavy metals **Biosurfactants in bioremediation**	9
4	**Emerging Techniques:** Role of biosensors in bioremediation Nanomaterials for bioremediation of air pollution **Phytoremediation and its processes**, role of phytochelatins**.** **Applications of genetic engineering in phytoremediation.** Algal and fungal-based bioremediation., **Biomonitoring** - Application of Microbial Enzymes - Construction of Biomembrane Reactors for Bioremediation Biodegradation of polyhalogenated compounds by genetically engineered bacteria.	9

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
● 2 Questions from each module. ● Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	● Each question carries 9 marks. ● Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to: Understand the role of various bioremediation techniques in removing pollutants from the environment in an affordable, nontoxic and environmentally friendly way.

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Elaborate on the different types of bioremediation process and the metabolic processes associated with bioremediation	**K2**
CO2	Relate the bioremediation strategies and kinetics for biodegradation process.	**K2**
CO3	Illustrate the various techniques associated with remediation of soil, water and heavy metals	**K2**
CO4	Summarize the emerging techniques used in the process of bioremediation	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	3											
CO3	2						3	2				
CO4	2				2		3	2				

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Biotechnology, Principles and Applications by,	Bruce E Rittman and Perry L McCarty	McGrawhill Higher education	2nd 2001
2	Biodegradation and bioremediation	Martin Alexander	Academic press	2nd 1999
3	Biodegradation and bioremediation	Singh A, Ward OP	Springer-Verlag	2004
4	Bioremediation	Baker KH	Mc Graw Hill	2nd 1999

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioremediation and Natural Attenuation	Pedro J J Alvarage and Walter A Illman	Wiley Interscience.	2nd 2006
2	Environmental Biotechnology	Agawal K	APH publishing	2000
3	Bioremediation Current Research and Application	Ashok K Rathoure	TechSar Pvt. Ltd	1st 2017
4	Approaches in Bioremediation	Ram Prasad Elisabet Aranda	Springer	2018

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt41/preview
2	nptel.ac.in/courses/102/105/102105088/
3	https://onlinecourses.nptel.ac.in/noc20_ce31/preview
4	https://onlinecourses.nptel.ac.in/noc24_ce11/preview

SEMESTER S7

PROTEOMICS & PROTEIN ENGINEERING

Course Code	**PEBBT756**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Foundation in Molecular Biology and Cell Biology	**Course Type**	Theory

Course Objectives:

This course introduces the student to the molecular and cellular principles behind how a single cell becomes a multicellular organism with specialized tissues and organs. The students will learn

1. To ask the key questions in development
2. How cells communicate in promoting the development of a multicellular organism
3. How the body plan of a multicellular organism is patterned to give rise to specialized tissues and organs
4. To appreciate the conservation of the molecular and cellular principles across different species
5. To understand the influence of the external environment in the developmental process, and
6. To analyse and integrate the scientific data that are used to answer all these questions in development.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of protein chemistry** Proteomics and its application, Functional proteomics in post genomic era, Proteomics experimental workflows, Gene-Protein families link with examples, Human proteome draft **Application of Chromatography in proteomics** Application of separation techniques in proteomics - Multidimensional chromatography, use of nanoLC, COFRADIC combined fractional diagonal chromatography, HILIC-hydrophilic interaction liquid chromatography,	9

	SAX- strong anion exchange chromatography, SCX- strong cation-exchange chromatography, affinity chromatography, reverse phase	
2	**Abundance based Proteomics** Gel based proteomics. Variations in 2-D gel electrophoresis, Difference Gel Electrophoresis (DIGE), and Mass spectrometry based proteomics- Analysis of data, MALDI, SELDI, Peptide mass fingerprinting, Protein microarray (analytical, functional, reverse phase), protein sequencing **Structural Proteomics** Application of X-ray crystallography, Circular Dichroism, Nuclear Magnetic Resonance, Plasmon Resonance, Small Angle X-ray Scattering	**9**
3	**Post-translational modification and Tagging of Proteins** Analysis of posttranslational modifications, Phosphorylation, ubiquitination (poly and mono), acetylation, nitration, glycosylation, Sumoylation, disulphide bond formation, signal peptide cleavages. Tagging of proteins with chemical and genetic approaches **Targetted Proteomics – Macromolecular Interactions** Qualitative and quantitative proteome analysis, Short-gun proteomics for proteome profile (whole proteome and sub-proteome analysis), Expression proteome analysis (isotope-labeling and label-free approaches), Proteomic analysis of protein-protein (including antigen-antibody interactions for epitope mapping), protein-DNA interactions, Identification of ligand receptor pairing and transcriptional regulators.	**9**
4	**Proteomics in Clinical and Drug Discovery Applications** Proteomics in study of diseases, Storage transportation and processing of clinical samples, Proteomic analysis of body fluids, Western Blotting, systems biology approaches and interaction network for drug discovery **Protein Engineering** Proteins design and engineering, Random, site directed mutagenesis; Strategies to alter catalytic efficiency; structure prediction and modeling proteins; Molecular graphics in protein engineering; Dynamics and mechanics; Drug-protein interactions and Design; applications of engineered proteins.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the knowledge of protein structure and function understanding in designing strategies for proteomic analysis and protein engineering.	**K3**
CO2	Analyse proteomic data using databases	**K4**
CO3	Solve problem related to protein function and efficiency with tools and techniques for protein engineering and	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	2
CO2	3	3	2	1	1	1	-	-	-	-	-	2
CO3	2	3	2	1	1	1	1	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Proteomics	R.M. Twyman	Bioscientific Publishers	2013
2	Biotechnology	David Clark and Nanette Pazdernik.	2nd Edition, Academic Cell.	2015
3	Molecular Biology of the Cell	B. Alberts,D.Bray, J.Lewis et al,	Garland Pub. N.Y	1983
4	Proteomics in Practice: A Guide to Successful Experimental Design	Westermeier R Naven T	Wiley-VCH	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Proteomics: Methods and Protocols (2017), Methods in Molecular Biology Series	Humana Press. USA.	Ed. Lucio Comai · Jonathan E. Katz Parag Mallick	2017
2	2006) Protein Biochemistry and Proteomics (The Experimenter Series)	Hubert R	Academic Press	2006
3	(2009) Proteomics: A Cold Spring Harbor Laboratory Course Manual	Link AJ, LaBaer J	Cold Spring Harbor Laboratory Press	2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc20_bt20/preview
2	https://onlinecourses.nptel.ac.in/noc24_bt40/preview
3	https://archive.nptel.ac.in/courses/102/101/102101055/
4	https://archive.nptel.ac.in/courses/102/103/102103017/

SEMESTER S7

NEXT GENERATION SEQUENCING TECHNOLOGIES: DATA ANALYSIS AND APPLICATION

Course Code	**PEBBT755**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Foundation in Genomics & Bioinformatics	**Course Type**	Theory

Course Objectives:

By the end of the course, students will be able to

1. Understand the molecular basis of NGS
2. Have a detailed vision of NGS Applications and Opportunities in Science and Medicine
3. Apply practical skills in NGS data analysis
4. Transform the outputs from the NGS platforms into biologically meaningful datasets
5. Interpret NGS data
6. Identify in silico genomics and bioinformatics tools for post-analytical data interpretation
7. Extract, score, sort, and filter NGS findings based on a) Technical quality b) Biological priority c) Potential Pathogenicity d) Statistical considerations
8. Design NGS-based approaches for clinical and research applications

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to the three generations of sequencing:** First (Sanger) and Second (Massively Parallel) Generations of Sequencing. Examples. Comparative overview of the available platforms: Illumina, Roche, Applied Biosystems, Principles, Advantages, and Challenges	**9**
2	**Third (Single Molecule Real Time) Generation of Sequencing**. Examples. Comparative overview of the available platforms: Helicos Biosciences, Oxford (Nanopore), Pacific BioSciences - Principles,	**9**

	Advantages and Challenges. Overview of the three generations of sequencing	
3	**Applications of NGS**: Enrichment libraries II: ChIP and ATAC sequencing, Hi-C Sequencing – Molecular Principles and Approaches for Enrichment (capture, immunoprecipitation, DNA crosslinking). Single Cell Sequencing **Microbiome** – sequencing, analysis, data mining	**9**
4	**Basics of Script-writing and programming for NGS data analysis** Intro to data analysis - Bulk and Single-cell RNA sequencing analysis: Part1 Alignment, Assembly, Abundance estimation, Splice Isoforms Assessment. Bulk and Single-cell RNA sequencing analysis: Variation calls, Variation Annotation	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify the different NGS technologies in the market	**K2**
CO2	Evaluate the main variables that influence the design of a sequencing project	**K5**
CO3	Analyse NGS data using *in-silico* genomics and bioinformatics tools	**K4**
CO4	Design NGS-based approaches for clinical and research applications	**K6**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				2						2
CO2	3	3		2	3	2						2
CO3	3	3		2	3	2						2
CO3	3	3	3	2	3	2						2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Next-Generation Sequencing, Methods and Protocols	Steven R. Head, Phillip Ordoukhanian, Daniel R. Salomon	2018, Volume 1712, (Eds), Humana Press. ISBN : 978-1-4939-7512-9	2020
2	Next-Generation Sequencing and Data Analysis	Melanie Kappelmann-Fenzl	Springer.ISBN : 978-3-030-62489-7.	2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Applied computational genomics.	Yin Yao, S.	1st Edition, Springer, Netherlands	2012
2	Advances in genome science	Atta-ur-Rahman.	1st Edition, Bentham Science Publishers, UAE.	2016
3	Dictionary of DNA and Genome Technology	Singleton, P.	1st Edition, John Wiley and Sons, New Jersey, USA.	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc23_bt34/preview
2	
3	
4	

SEMESTER S7

MICROBIAL FUEL CELL

Course Code	OEBBT721	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL.	Course Type	Theory

Course Objectives:

1. To impart fundamental principles, and review the state of the art, design, economics, and future perspectives of current and emerging biologically-based processes for energy production.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to bioenergy - bioenergy policies and initiatives (global and national), various renewable feedstock for bioenergy production, their availability and characteristics, energy yields from the conversion of energy crops to biofuels: challenges in applying sustainable bioenergy systems and their further development.	9
2	Bioelectrical systems - microbial fuel cells, microbial electrolysis cells, other bioelectrical systems-basic principles, state-of-the-art processes, efficiency enhancement, design, life cycle analysis, and environmental implications, emerging bioelectrical systems.	9
3	Biohydrogen - prospects of biohydrogen as a potential energy resource, basic principles, various biohydrogen production processes, dark and photo fermentation, biological kinetics and yields - strategies to improve process efficiency, major challenges, cell engineering, and emerging applications - design, life cycle analysis, and environmental implications.	9
4	Life cycle analysis and sustainability of bioenergy systems, social, environmental, and economic impacts biofuels, feedstock costs, capital costs, operating costs, food vs. fuel debate, Case studies of Hydrogen, Ethanol, and Biodiesel Production.	9

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Basic principles of biologically-based processes for energy production.	**K1**
CO2	Understand the social, environmental, and economic impacts of biofuels.	**K2**
CO3	Apply working principles of microbial fuel cells and other bioelectrical systems.	**K3**
CO4	Identify renewable feedstock for bioenergy production.	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	1	-	-	-	-	-	-	-	-	2
CO2	2	-	-	2	-	-	-	-	-	-	-	2
CO3	2	-	2	2		-	-	-	-	-	-	2
CO4	3	2	-	3	-	-	-	-	-	-	-	2

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Fuel Cell Fundamentals,	R. O'Hayre, S-W. Cha, W. Colella, F. B. Prinz	John Wiley and Sons, USA	2005
2	Principles of Fuel Cells	X. Li	CRC Press, USA	2005
3	Transport Phenomena in Fuel cells	Ed. B. Sunden and M. Faghri	WIT Press, UK	2005
4	Biofuels Engineering Process Technology	Caye Drapcho, John Nghiem, Terry Walker	McGraw-Hill	2008
5	Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers	Shang-Tian Yang, Hesham El-Ensashy, Nuttha Thongchul	John Wiley & Sons	2013

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Biofuels and Bioenergy: Processes and Technologies	Sunggyu Lee, Y.T. Shah	CRC Press	2013
2	Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers	Shang-Tian Yang, Hesham El-Ensashy, Nuttha Thongchul	John Wiley & Sons	2013
3	Anaerobic Biotechnology for Bioenergy Production: Principles and Applications.	Samir K Khanal	Wiley-Blackwell	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/102/103102015/
2	https://archive.nptel.ac.in/courses/115/105/115105127/
3	ww.ndl.gov.in/he_document/nptel/nptel/courses_103_107_103107125_video_lec29
4	

SEMESTER S7

ADVANCED MATERIALS

Course Code	OEBBT722	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To impart knowledge of properties and applications of various types of advanced materials

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Classification and structure property relations of materials:** Importance of Engineering materials, classification of materials, classification of materials- basic categories (metals, ceramics, and polymers), Composite materials and advanced materials: semiconductors, biomaterials, smart materials, and nanoengineered materials. Amorphous and semi-crystalline materials, mechanical, thermal and electrical properties of materials and their dependence on the microstructure, elastic and plastic behaviour of metals, ceramics and polymers, changes in the microstructure of materials due to mechanical and thermal load, length scales relevant for materials and their characterization.	**8**
2	**Metal alloys:** Types of metal alloys, processing and applications of metal alloys. **Ceramics:** types processing and applications of ceramics advanced ceramics, mechanical properties, processing and applications. **Polymers:** Classification, properties, processing and applications.	**10**

	Composites: particle-reinforced composites, Fiber-reinforced composites- Characteristics, synthesis and applications of composites. **Biomaterials:** Types of Biomaterials: Natural and Synthetic, Properties and Biocompatibility, Applications in Medical Devices, Implants, and Tissue Engineering.	
3	**Nanomaterials and nanocomposites:** advanced nano-materials - synthesis, properties and applications – fullerenes, graphene, graphite, carbon nano-tubes, nano wires, nano rods, nanofluids, nanoclusters. Nanocomposites - Matrix materials- Basics of Metal matrix, Ceramic Matrix and Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers. Introduction to bionanotechnology (fundamental concepts only) - Nanomedicine, Drug delivery, Therapeutic applications. Applications of biosensors,	**9**
4	**Smart materials:** Types of smart materials, thermochromic and photochromic materials, Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, , piezoelectric ceramics: Principles of Piezoelectricity, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, properties and applications, magnetostrictive materials: Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, properties and applications, Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC)	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Summarize the important factors that affect the behaviour of materials under different conditions.	**K2**
CO2	Compare the physical properties of metals, alloys, polymers, ceramics, and composites significant in various engineering applications.	**K2**
CO3	Explain different types of advanced nanomaterials, nanocomposites , their methods of synthesis and applications.	**K2**
CO4	Explain the key theory and operation principles of smart materials, their synthesis, properties and applications.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3											
CO3	3											
CO4	3	2										

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Materials Science and Engineering An Introduction	William D. Callister, Jr.	Wiley	Tenth, 2018
2	The science of Engineering of Materials	Donald. R Askeland	Cengage learning	Sixth, 2010
3	Nanostructures & Nanomaterials: Synthesis, Properties & Applications	Joel I. Gersten	Wiley	2001
4	Nanocomposite science and technology	Pulikel M. Ajayan	Wiley	2005
5	Engineering analysis of smart material systems.	Donald J. Leo	John Wiley & Sons	2007

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bionanotechnology	David S Goodsell	John Wiley & Sons,	2004

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	
2	https://nptel.ac.in/courses/113/104/113104009/
3	https://onlinecourses.nptel.ac.in/noc19_mm21/preview
4	https://nptel.ac.in/courses/112104173

SEMESTER S7

PROCESS SAFETY ENGINEERING

Course Code	OEBBT723	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)		Course Type	Theory

Course Objectives:

1. Impart the basic concepts of safety in Process Industries.
2. Apply engineering fundamentals on fire safety by fire prevention and flammability diagram.
3. Identify various hazards associated with chemical process industries.
4. Develop an understanding about safety practices in industries and emergency planning.
5. Incorporate inherent safety, Hazard analysis techniques, and awareness about government agencies, regulatory bodies, codes, and standards that govern the global, societal, and environmental impact.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to safety:** Concept and importance of industrial safety. Fundamental safety tenets. Safety in the site selection and lay out. Review of Industrial Accidents- Major Chemical Industry Accidents, Bhopal, Flixborough, SEVESO. Cost of accidents. Key safe practices in chemical industry for accident prevention programme. Material safety data sheet (MSDS). Work permit system, Personal Protective Equipment's (PPE).	9
2	**Fire & Safety:** Classification of Fire- Pool fire, Jet fire, Flash fire, Explosion-UVCE, BLEVE, Dust explosion, Deflagration, Detonation. Toxic release, Runaway Reaction. Fire pyramid. Types of fire extinguishers and its	9

	handling. Fixed fire protection systems. Flammability diagram- construction, application. Hazards in a process industry: Classification, consequences of chemical hazards, physical hazards, electrical hazards, mechanical hazards and environmental hazards.	
3	**Prevention techniques for hazards:** Hazardous area classification. Safety in transportation of hazardous chemicals by road-HAZCHEM CODE, TREM CARD Relief system and Detectors. T.L.V, STEL, TLV-C, IDLH, UFL, LFL. Hazard rating of chemical plants- Dow index and Toxicity index. Emergency planning-onsite and offsite emergency planning, Mock drill.	**9**
4	**Safety analysis:** Safety Inspections, Safety Audits, safety Analysis, Hazard Survey and analysis, HAZOP, Bow tie diagram, Fault tree analysis, failure mode and effect analysis, Event tree analysis, examples. Safety integrity level (SIL). The concept of inherent safety. Occupational Health and Safety Administration, Safety provisions in Factories Act.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Summarize the basic concepts of safety in process industries.	**K2**
CO2	Apply engineering fundamentals on fire safety by fire prevention and flammability diagram.	**K3**
CO3	Develop an understanding about safety practices in industries and emergency planning.	**K3**
CO4	Select inherent safety, Hazard analysis techniques, and awareness about government agencies, regulatory bodies, codes, and standards that govern the global, societal, and environmental impact.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3		2			3						
CO2	3		2			3						
CO3	3		2			3						
CO4	3		2			3						

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Safety in Chemical Plants/Industry and Its Management	B. K. Bhaskara Rao, Er. R. K. Jain, Vineet Kumar	Khanna Publishers	1st edition, 2010
2	Industrial Safety, Health and Environment Management Systems	R. K. Jain & Sunil S Rao	Khanna Publishers	4th Edition,2000

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Encyclopaedia of Occupational Health & Safety		International labour Office, Geneva,	2012
2	Loss Prevention in Process Industries	Frank P. Lees	Butterworth-Heinemann	Vol.1,2&3,2nd Edn,.1996
3	Guidelines for Hazard Evaluation Procedure		Centre for Chemical Process Safety. AICHE	1992
4	Methodologies in Hazard Identification and assessment	K.V. Raghavan and A. A. Khan	Manual by CLRI	December 1990
5	Chemical Process Safety Fundamentals with applications	Daniel A. Crowl/ Joseph F. Louvar	Prentice Hall international series.	2nd Edition
6	Chemical Process Industrial safety	K.S.N Raju	McGraw Hill	2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/105/110105094/
2	http://www.digimat.in/nptel/courses/video/103107156/L42.html
3	https://archive.nptel.ac.in/courses/103/107/103107156/

SEMESTER S7

INDUSTRIAL INSTRUMENTATION

Course Code	OEBBT724	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. To study about different instruments and techniques used in chemical industry for measurement of various process variables and understand the theory behind them.
2. To understand the range of applicability and characteristics of these instruments.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction-definition of instrumentation:** concept of an instrument-functional elements and functions of an instrument. classification of instruments. Performance characteristics of an instrument like static and dynamic type. Temperature measurement- electrical,non-electrical, contact and non-contact methods, thermometers of three types like liquid-filled, vapour pressure and gas-filled type, bimetallic thermometers, resistance thermometers, thermocouple type-thermoelectric principles like Seebeck effect, Peltier effect & Thomson effect and the laws of thermoelectricity-thermocouple output measurement. Radiation methods-radiation and optical pyrometry. Thermistors-resistance characteristics and their application in temperature measurement	9
2	**Pressure measurement:** manometers of U-tube type, well type and inclined type. Prandtl and air type micromanometers. Barometer method for atmospheric pressure measurement. Low pressure measurement by kenetometer, McLeod gage, thermal conductivity gauge, Pressure measurement using bourdon tube, flat and corrugated diaphragms, and	9

	capsules. Measurement of pressure in corrosive fluids using liquid seal and diaphragm seal. Transducers of electrical and mechanical type. Density measurement using constant volume hydrometer and air pressure balance method, gas density detector and gas specific gravity measuring system.	
3	**Flow measurement:** using head type flowmeters based on differential pressure measurementorifice meter, venturi meter, flow nozzle and pitot tube. Open channel meters like weirs, flumes. Electromagnetic flowmeters. Variable area meters like rotameter and cone and float type. Mechanical flowmeters of positive displacement type like rotating disk and turbine type & anemometers. Level measurement-direct type and indirect type. Differential pressure method for pressurized vessels. Solid level detectors.	**9**
4	**Moisture content and humidity:** definition, moisture content determination by thermal drying. Instruments for measuring humidity like hygrometer, psychrometer, dew point apparatus. pH measurement using calomel electrode. Composition analysis using spectroscopic methods like absorption, emission and mass spectrometers. Analysis of solids by X-ray diffraction. Gas analysis by thermal conductivity, polarography & chromatography.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the various techniques used for the measurement of industrial parameters.	**K2**
CO2	Illustrate theworking of variousinstruments used for measurement of temperature, pressure and density in process plants.	**K2**
CO3	Summarize various types of flow measurement and level measurement transducers and their installation.	**K2**
CO4	Summarize the humidity and moisture measurements adopted in industrial environment.	**K2**
CO5	Illustrate analytical instruments.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2	3				2							
CO3	3				2							
CO4	3				2							
CO5	3				2							

Text Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Principles of Industrial Instrumentation	D. Patranabis	Tata McGraw Hill,	2ndEdition, New Delhi, Reprint2009.
2	Industrial Instrumentation & Control	S. K. Singh	Tata McGraw Hill,	3 rd Edition, Reprint2009.
3	Industrial Instrumentation	K.Krishnaswamy&S.Vijayachitra	New age International	Reprint 2008.

Reference Books

Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Mechanical & Industrial Measurements	R.K.Jain	Khanna Publishers	11th Edition, 2004.
2	Measurement Systems Application & Design	Ernest O. Doeblin, Dhanish. N. Manik,	TMH	5th Edition, 2004.

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/103/105/103105130/
2	https://archive.nptel.ac.in/courses/103/105/103105130/
3	https://archive.nptel.ac.in/courses/103/105/103105130/
4	https://archive.nptel.ac.in/courses/103/105/103105130/

SEMESTER S7

ADVANCED WASTEWATER TREATMENT

Course Code	**OEBBT725**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

Course Objectives:

This course will enable students to

1. Gain knowledge of advanced wastewater technologies
2. Understand the design and operation of the wastewater treatment process
3. Study on Electrochemical wastewater treatment processes and advanced oxidation processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of Advanced Waste Water Treatment:** Need of Advanced wastewater treatment, Technologies used for Advanced waste water treatment-Classification of Technologies. Nutrient Removal –Nitrogen Removal: Nitrification , Denitrification, Simultaneous nitrification and denitrification. Phosphorus Removal : Introduction, Phosphorus removal by Chemical Precipitation: Principles of process, Chemicals applied, Chemistry of phosphorus precipitation, Process configuration, Phosphorus removal by Biological Precipitation: Principles of the process, Microorganisms involved in the process, Process configurations.	**9**
2	**Wastewater Treatment: Primary treatmen**t: Screening, Grit removal, Neutralization, equalization, Sedimentation, Flotation (oil & grease removal), Air stripping. **Secondary treatment:** principles of waste treatment, basic kinetic equation, continuous flow treatment models, oxygen requirement in aerobic process, production of sludge. Conventional biological process: Activated Sludge Process (ASP)- development of	**9**

	material balance equations, Trickling Filters , UASB and RBC anaerobic filters. Low-cost wastewater treatment: Aerated lagoons, stabilization ponds, oxidation ditches.	
3	**Advanced Treatment Options: Tertiary treatment** – ion exchange, Membrane separation Techniques: Brief description of MF, UF, NF membranes. Reverse osmosis principle, Membrane materials, Types of membranes – Plate & frame, tubular, hollow fibre, spiral wound membranes. Adsorption: Introduction, Fundamentals of adsorption, Type of adsorbents ,Activated carbon adsorption, Granular carbon adsorption.	**9**
4	**Electrochemical Wastewater Treatment Processes:** Introduction, Electro-coagulation : Factors affecting Electrocoagulation, Electrode materials , Reactor configurations. Electro-floatation : Factors affecting electro floatation, Comparison with other technology, Reactor configurations, Electro-oxidation : Electro oxidation process, Reactor configurations.Advanced Oxidation Processes: Theory of advanced oxidation, Types of oxidizing agents, ozone based and non- ozone based processes, Fenton and photo-Fenton Oxidation. Solar Photo Catalytic Treatment Systems.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply the concepts of advanced technologies in Wastewater treatment	**K3**
CO2	Analyse primary and secondary treatment methods	**K4**
CO3	Select the most appropriate processes for the tertiary treatment of wastewater	**K3**
CO4	Explain different types of electrochemical treatment options for wastewater treatment	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3					2					2
CO2	3	3					2					3
CO3	3						2					3
CO4	3						2					

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Wastewater Engineering – Treatment and Reuse	Metcalf & Eddy	4th edition. Tata McGraw-Hill	2003
2	Water and Wastewater Technology	Mark.J.Hammer&Mark.J. Hammer J	Prentice Hall of India. Ltd.	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Engineering	Peavy, Rowe &Tchobanoglous	MCGraw-Hill	2015
2	Unit Processes in Water and Wastewater Engineering	Casey, T.J.,	Wiley Interscience	1997
3	Membrane Separation Processes	Kaushik Nath	PHI	2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/agZwWMN0C2c
2	https://youtu.be/6nM1bShwRNw
3	https://youtu.be/_LSKHSQmwwE,https://youtu.be/RW6jiE-K6rA ,https://youtu.be/WR2Pinj81Nk
4	https://youtu.be/0Dpv7-s-uqM ,https://youtu.be/7h5cuXiAQak , https://youtu.be/ni6NtEjrFLA

SEMESTER S7

AIR POLLUTION CONTROL

Course Code	OEBT726	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To understand the atmospheric pollutants, standards, regulations, emission sources, and their fate.
2. To imbibe the fundamentals of atmospheric stability and air pollutant transport, characteristics of emission sources, and their control methods.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Structure and composition of Atmosphere – Definition, Scope, and Scales of Air Pollution- Sources and classification of air pollutants-Effect on human health, vegetation, animals, property, aesthetic value and visibility- Ambient Air Quality and Emission standards–Ambient and stack sampling and Analysis of Particulate and Gaseous Pollutants.	9
2	Effects of meteorology on Air Pollution - Fundamentals, Atmospheric stability- Dry adiabatic lapse rate derivation, Inversion, Wind profiles and stack plume patterns- Atmospheric Diffusion Theories–Dispersion models, Plume Rise-Numerical Problems.	9
3	Gas Particle Interaction – Working principle, Design, and performance equations of Gravity Separators, Centrifugal separators, Fabric filters, Particulate Scrubbers, Electrostatic Precipitators – Operational Considerations- Factors affecting Selection of Control Equipment	9
4	Working principle, Design, and performance- equations of absorption, Adsorption, condensation, Incineration, Bio scrubbers, Venturi scrubber-Biofilters.	9

	Sources types and control of indoor air pollutants- sick building syndrome types – HVAC system issues and impacts on occupants—Developing an IAQ profile-Diagnose IAQ problem- Control-Quantification and Measurement.	

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	60

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Define the sources, classifications, effects of air pollutants.	**K1**
CO2	Explain the ambient air quality standards as well as sampling and analysis of air pollutants from emission sources.	**K2**
CO3	Outline the concepts of atmospheric dispersion characteristics and nature based on lapse rate and inversion.	**K2**
CO4	Explain the selection strategies and types of equipment and its design to control particulates and gaseous pollutants	**K2**
CO5	Explain the indoor air pollution sources, measurements, standards and control methods.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	3					3
CO2						3	3	3				3
CO3	2	3					3					2
CO4			3				3					2
CO5							3					3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Air Pollution Control Engineering,	Lawrence K. Wang, Norman C. Pareira, Yung Tse Hung,	Humana Press Inc.	Second, 2004
2	Air Pollution Control Engineering,	Noel de Nevers	Mc Graw Hill	Second, 1999
3	Air Pollution and Control Technologies,	Anjaneyulu. Y,	Allied Publishers (P) Ltd.	First, 2002
4	Environmental Pollution Control Engineering	C.S.Rao	Wiley Eastern Ltd,	Third, 2018
5	Handbook of Air Pollution Prevention and Control,	Nicholas P. Cheremisinoff	Butterworth and Heinemann, Elsevier Science (USA), 2002	2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Air Pollution	David H.F. Liu, Bela G. Liptak	Lweis Publishers	First, 2000
2	Air Pollution (Vol.I – Vol.VIII)	Arthur C.Stern	Academic Press	First, 2006
3	Air Pollution Engineering Manual	Wayne T.Davis,	John Wiley & Sons, Inc.	First, 2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/105107213
2	https://nptel.ac.in/courses/105107213
3	https://nptel.ac.in/courses/105107213
4	https://nptel.ac.in/courses/105107213

SEMESTER S7

DESIGN OF EXPERIMENTS

Course Code	OEBBT727	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Mathematics: Probability and statistics	Course Type	Theory

Course Objectives:

1. To help the students to explore innovative strategies for constructing and executing experiments including factorial and fractional factorial designs.
2. To help the students in extraction of meaningful data from well-designed minimal number of experiments at the lowest possible material costs.
3. To help the students to apply statistical models in anlysing experimental data and optimise the response of interest from an experiment.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to DoE**: Strategy of experimentation, Typical applications of Experimental design ,basic principles of experimental design : replication, randomization and blocking, Guidelines for designing the experiments Basic statistical concepts:- Concept of random variable, probability, density function, cumulative distribution function, measure of central tendency,measures of variability, sampling and sampling distribution, Statistical distributions: Normal, Log normal & Weibull distributions, Hypothesis testing.	9
2	**Experiments with single factor:The analysis of Variance** Analysis of fixed effect model, Model adequacy checking, contrasts, Orthogonal contrasts, Regression models and ANOVA, Violation of Normality Assumption: Kruskal-Wallis test. Randomized block designs, Latin square designs, Balanced Incomplete Block Designs	9

3	**Factorial designs:** Definition, Estimating model parameters, Fitting response curves and surfaces.The 2k Factorial Design, Blocking and Confounding in the 2^k Factorial Design; Focus of 2^2 and 2^3 designs, Blocking and Confounding in the 2^k Factorial Design	**9**
4	**Regression analysis** :Linear and multiple linear regression, Estimation of parameters in linear regression models, Hypothesis testing in multiple regression, Confidence intervals in multiple regression, Regression model diagnostics, Testing for lack of fit **Response surface methodology**: Introduction, Method of steepest ascent, Response surface designs for first-order models, analysis of a second order response surface , Central composite design	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain basic principles of design of experiments.	**K2**
CO2	Inspect statistical analysis of single experiments and do post hoc analysis.	**K4**
CO3	Analyze the experimental data using statistical methods.	**K4**
CO4	Choose an appropriate design for the given the research problem	**K5**
CO5	Examine regression analysis and response surface methodology and apply them in real life applications	**K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	3									3
CO2	3	3	3	3	3					3		
CO3	3	3	3	3	3					3		
CO4	3	3	3	3	3							3
CO5	3	3	3	3	3							3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Design and Analysis of Experiments, , Inc. 2013	Douglas C. Montgomery	John Wiley & Sons	8th Edition,2013
2	Statistics for Experimenters: Design, Innovation, and Discovery,	Box, G. E., Hunter, W.G., Hunter, J.S., Hunter, W.G	Wiley	2nd Edition, 2005
3	Response Surface Methodology: Process and Product Optimization using Designed Experiments	R. H. Myers, D. C. Montgomery	Wiley	4^{th}edn, 2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Statistical Quality Control	D. C. Montgomery.	John Wiley & Sons	8th edn, 2019
2	Design of Experiments in Chemical Engineering:	Živorad R. Lazić	Wiley	1st edn, 2004

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/105/110105087/
2	https://archive.nptel.ac.in/courses/110/105/110105087/
3	https://archive.nptel.ac.in/courses/110/105/110105087/
4	https://archive.nptel.ac.in/courses/110/105/110105087/

SEMESTER 8

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

Common for

BIOTECHNOLOGY ENGINEERING

SEMESTER S8

CYTOGENETICS

Course Code	**PEBB861**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge in Molecular Biology	**Course Type**	Theory

Course Objectives:

This course will enable students to understand

1. The developments in the field of cytogenetics, Chromosome banding, chromosomal pathologies:
2. Numerical and Structural aberrations in the chromosomes and their common syndromes
3. Various technologies related to the field of cytogenetics and apply them in identifying human disorders

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to genetics, chromosome structure, function, and abnormalities Introduction to cytogenetics-DNA-chromosomes and cell division, chromatin, chromosome replication and its segregation, structure of chromatins, Nucleosomes, centrosome, Karyotype analysis, Sex determination, and sex chromosomes, Sex chromosome X and Y, Structural chromosome abnormalities, Chromosome inactivation, Variations in chromosome number and structure	9
2	Mendelism, inheritance and genetic diseases Mendelism, the basic principles of inheritance, the chromosomal basis of Mendelism, chromosomal rearrangement associated with Mendelian disorders-Eukaryotic chromosome-Telomeres-Extrachromosomal replicons-linkage-crossing over-	9

	chromosome mapping in eukaryotes-Genetic diseases X-linked, autosomal inheritance-chromosome rearrangements, inversions, translocations	
3	Developmental, population, and evolutionary genetics Inheritance of complex traits, Genetic control of development-sex determination of Drosophila, C. Elegans, Zygotic gene activity in development-population genetics-evolutionary genetics, variation in phenotypes, chromosome structure, nucleotide sequences, molecular evolution, genetics of speciation	**9**
4	Molecular cytogenetics and techniques Cytogenetic approaches for studying human diseases-cancer cytogenetics-molecular cytogenetics, and Techniques Fluorescence in situ hybridization-comparative genomic hybridization, Array comparative genomic hybridization, multi-color fluorescence in situ hybridization, fluorescence in situ hybridization detection of HER2 amplification	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand genomic architecture, chromosome functions, and the relationship of nuclear structure to function	**K2**
CO2	Apply the knowledge of chromosome organization and decipher the relation between chromosome copy number and diseases	**K3**
CO3	Illustrate the techniques used in the study of chromosome and DNA	**K2**
CO4	Describe the principles of clinical cytogenetics and diagnostics	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2										2
CO2	3	2										2
CO3	3	2										2
CO4	3	2										2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Principles of Genetics	Peter Snustad & Michael J. Simmons	, 7th edition, 2015 ISBN: 978-1-119-14228-7	2015
2	Concepts of Genetics	Michael R. Cummings, William S. Klug, Charlotte A. Spencer, Michael A. Palladino and Darrell Killian	12th Global Edition 2019 ISBN 9781292265322	2019

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Lewin, 's GENES XII,	Jocelyn E. Krebs, Elliott S Goldstein, Stephen T. Kilpatrick	12th edition, 2018, ISBN 9781284104493	2018
2	Molecular Cytogenetics	Barbara Ann Hamkalo, John Papaconstantinou	ISBN 978-1-4615-7481-1 2012	2012

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt02/preview
2	
3	
4	

SEMESTER S8

DRUG DELIVERY PRINCIPLE & APPLICATION

Course Code	**PEBB862**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge in Microbiology and Cell Biology	**Course Type**	Theory

Course Objectives:

Upon completion of the course student shall be able

1. To understand various approaches for development of novel drug delivery systems.
2. To understand the criteria for selection of drugs and polymers for the development of Novel drug delivery systems, their formulation and evaluation
3. Grasp the current regulatory acts and safety norms of the modern pharmaceutical industries

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Controlled drug delivery systems:** Introduction, terminology/definitions and rationale, advantages, disadvantages, selection of drug candidates. Approaches to design controlled release formulations based on diffusion, dissolution and ion exchange principles. Physicochemical and biological properties of drugs relevant to controlled release formulations **Polymers:** Introduction, classification, properties, advantages and application of polymers in formulation of controlled release drug delivery systems.	9

2	**Microencapsulation:** Definition, advantages and disadvantages, microspheres /microcapsules, microparticles, methods of microencapsulation, applications **Mucosal Drug Delivery system:** Introduction, Principles of bioadhesion/ mucoadhesion, concepts, advantages and disadvantages, transmucosal permeability and formulation considerations of buccal delivery systems **Implantable Drug Delivery Systems:** Introduction, advantages and disadvantages, concept of implants and osmotic pump	**9**
3	**Transdermal Drug Delivery Systems:** Introduction, Permeation through skin, factors affecting permeation, permeation enhancers, basic components of TDDS, formulation approaches **Gastro-retentive drug delivery systems:** Introduction, advantages, disadvantages, approaches for GRDDS – Floating, high-density systems, inflatable and gastro-adhesive systems and their applications **Naso-pulmonary drug delivery system:** Introduction to Nasal and Pulmonary routes of drug delivery, Formulation of Inhalers (dry powder and metered dose), nasal sprays, nebulizers	**9**
4	**Targeted drug Delivery**: Concepts and approaches advantages and disadvantages, introduction to liposomes, niosomes, nanoparticles, monoclonal antibodies and their applications **Ocular Drug Delivery Systems:** Introduction, intra ocular barriers and methods to overcome –Preliminary study, ocular formulations and ocuserts **Intrauterine Drug Delivery Systems:** Introduction, advantages and disadvantages, development of intra uterine devices (IUDs) and applications	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Comprehend the factors influencing the bioavailability and bioequivalence of drugs.	**K2**
CO2	Design and analysis of Drug delivery systems	**K4, K5**
CO3	Recognize the formulation concepts and evaluate different dosage forms to meet out the compendial requirements.	**K2, K5**
CO4	Apply the knowledge of biomolecules for designing modern drug delivery components by understanding the principles of self-assembly and self-organization and apply them to biology	**K2, K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											3
CO2	3	3	2									3
CO3	3	3	2									3
CO4	3	3	2									3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Novel Drug Delivery Systems	Y W. Chien	Marcel Dekker, Inc., New York	2nd edition, revised and expanded, 1992.
2	Controlled and Novel Drug Delivery	N.K. Jain	CBS Publishers & Distributors, New Delhi	First edition 1997 (reprint in 2001).
3	Controlled Drug Delivery - concepts and advances	S.P. Vyas and R.K. Khar	Vallabh Prakashan, New Delhi	First edition 2002

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Encyclopedia of Controlled Delivery.	Edith Mathiowitz	Published by Wiley Interscience Publication, John Wiley and Sons, Inc, New York. Chichester/Weinheim	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc21_bt37/preview https://archive.nptel.ac.in/courses/102/108/102108077/

SEMESTER S8

MARINE BIOTECHNOLOGY

Course Code	**PEBB863**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge in Microbiology and Cell Biology	**Course Type**	Theory

Course Objectives:

1. The objective of this course is to provide information about the microbes available in aquatic environment, their role and interaction with the marine environment

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Types of marine environment - Physical, Chemical and Biological aspects, Marine organisms, Types of marine microbes and their biology; Introduction to marine pharmacology, Microbial metabolites, Microbial interaction Microbes of Biotechnological importance, Primary and secondary metabolite. Bioaugmentation, Biofouling, Corrosion Process and control of marine structures, Bioremediation, Nutrient cycling, Bio-fertilization	9
2	Probiotics, Regulation of bacterial growth, Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial), Biological indicators and accumulators. Marine resources assessment, Methods of surveying the living resources (Acoustic, Aerial and Remote sensing), Population study and Marine environment protection Population dynamics, Abundance and density, Growth and mortality (fishing & natural)	9

3	Algal biotechnology single cell protein, hydrocolloids, agarose, carrageen alginates and other byproducts. Marine Enzymes sources and their applications Marine Lipids sources and their applications.	**9**
4	Conservation and management- in situ and ex situ, IUCN categorization, Marine biosphere reserves, Marine parks -heritage sites. Chromosome manipulation in aquaculture – hybridization, Ploidy induction, Gynogenesis, Androgenesis and sex reversal in commercially important fishes, Transgenic fish, Tools for disease diagnosis in cultivable organisms	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Demonstrate a comprehensive understanding of the theories and processes involved in the production of marine pharmaceuticals	**K2**
CO2	Identify and analyse the various causes of marine pollution, ranging from industrial runoff to plastic waste, and develop strategies to prevent and mitigate these pollution sources	**K2, K3**
CO3	Assess the economic, ecological, and cultural importance of marine ecosystems and their role in maintaining biodiversity and ecosystem services	**K2, K3**
CO4	Analyze the theory and rationale behind the production of genetically modified fish, including the ethical considerations and environmental impacts associated with this technology	**K3, K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											3
CO2	3	3										3
CO3	3	3										3
CO4	3	3										3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Recent Advances in Marine Biotechnology	M. Fingerman, R. Nagabhushanam and M.-F. Thompson.	Science Publishers	1999
2	Frontiers in Marine Biotechnology	P. Proksch	Taylor & Francis,	1st Edn., 2006
3	Molecular Genetics of Marine Organisms, Illustrated	M. Fingerman and R. Nagabhushanam	Edn., Science Pub.	2004

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Biotechnology and Cleaner Bioprocesses	G. Sanchez and E. Hernandez	CRC press	1st Edn., I999

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.swayam2.ac.in/cec23_bt22/preview https://onlinecourses.nptel.ac.in/noc24_oe06/preview

SEMESTER S8

ENVIRONMENTAL BIOTECHNOLOGY

Course Code	**PEBBT864**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	2:1:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Knowledge Of Microbiology, Biochemistry, Bioreactors	**Course Type**	Theory

Course Objectives: This course will enable students

1. To know the importance of biodegradation
2. To recognise the microbial processes for the treatment of wastewater
3. To develop the various biological processes for wastewater treatment
4. To integrate the biotechnology concepts for the control of air pollution
5. To apply the knowledge for the development of bioproducts from renewable sources
6. To develop the biotechnological process for a clean and green environment

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Role of microbes in environmental biotechnology:** Prokaryotes-bacteria, archaebacteria, Eukaryotes -Fungi, algae, their applications in environmental issues. **Microbial metabolism in environmental biotechnology:** Overview of catabolism and anabolism. Microbial pathways of relevance to Environmental biotechnology. Fermentation and respiration. Electron and energy carriers. Oxidative phosphorylation.	8
2	**Stoichiometry and bacterial energetics:** Empirical formula for cells. Substrate partitioning and cellular yield. Energy reactions in bacterial energetics- Aerobic oxidation, denitrification, sulfate reduction,	8

	methanogenesis, ethanol fermentation.	
3	**Oxygen demand:** Biochemical Oxygen demand- sources of BOD, CBOD, and NBOD (BOD curve), BOD measurement by dilution method. COD- COD measurement. Dissolved oxygen sag curve. BOD Removal Kinetics. **Wastewater treatment:** Aerobic biofilm processes- basic principle, biofilm-based bioreactors – Trickling filters, activated sludge process, rotating biological contactors, fluidized bed reactors, circulating bed biofilm reactors, hybrid biofilm reactors.	**10**
4	**Microbial principles of biodegradation:** Mechanisms of biodegradation- oxidation, dehalogenation, cometabolism, biotransformation of metals. Bioremediation principle- biostimulation, bioaugmentation. Examples of bioremediation of aliphatic and aromatic compounds. Use of genetically engineered microbes for bioremediation- Advantages and disadvantages. Case studies on bioremediation.	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Outline the role of microbes in solving environmental issues and explain microbial metabolic pathways in various applications.	**K2**
CO2	Identify and define the important energy reactions in the stoichiometry of bacterial energetics.	**K1**
CO3	Illustrate various aspects of oxygen demand and biofilm processes for the aerobic treatment of wastewater.	**K2**
CO4	Demonstrate and apply various strategies for the bioremediation of hazardous compounds.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1	1			2			2	1	2
CO2	1	2	2	2	1		1			3	1	
CO3	3	3	3	2	2	2	2	2		2	2	2
CO4	3	3	3	3	2	2	3	2		3	2	3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Biotechnology: Principles and Applications	Bruce E Ritmann, Perry L McCarty	McGraw-Hill	2001
2	Environmental Biotechnology- Theory and Applications	Gareth M Evans, Judith C Furlong	John Wiley & Sons	2003
3	Environmental Biotechnology	Alan Scragg	Oxford University Press	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Biotechnology	T. Srinivas	New Age International	2008
2	Environmental Biotechnology	P R Yadav, Rajiv Tyagi	Discovery Publishing	2006

SEMESTER S8

BIOCONJUGATE TECHNOLOGY & APPLICATIONS

Course Code	PEBB866	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Foundation in chemistry, and biology	Course Type	Theory

Course Objectives:

1. This course will enable students to understand the latest research in medicinal and pharmaceutical chemistry and also the applications of the drug-loaded in the treatment of various diseases.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Functional Targets and Chemistry of Active Groups** Modification of Amino Acids, Peptides, and Proteins – Modification of sugars, polysaccharides, and glycoconjugates, modification of nucleic acids and oligonucleotides. Amine reactive chemical reactions, Thiol reactive chemical reactions, carboxylate reactive chemical reactions, hydroxyl reactive chemical reactions, aldehyde and ketone reactive chemical reactions, and Photoreactive chemical reactions.	9
2	**Bioconjugate Reagents** Bioconjugate Reagents-Zero length cross-linkers, Homobifunctional cross-linkers, Heterobifunctional cross-linkers, Trifunctional cross-linkers, Dendrimers and Dendrons, Cleavable reagent systems, tags and probes. Chemical properties of the bioconjugate reagents and the scheme used for cross-linking. Application of the bioconjugate reagents in industry, clinical	9

	care, and diagnosis.	
3	**Modification of Biological Macromolecules by Conjugation** Modification of Enzyme and Nucleic acid Properties of common enzymes, Activated enzymes for conjugation, biotinylated enzymes, chemical modification of nucleic acids, biotin labeling of DNA- enzyme conjugation to DNA, Fluorescent of DNA. Significance of the modified biological macromolecules.	9
4	**Applications of Bioconjugate Technology** Bioconjugate Applications- Preparation of Hapten-carrier Immunogen conjugates, antibody modification and conjugation, immunotoxin conjugation techniques, liposome conjugated and derivatives, colloidal–gold–labeled proteins, modification with synthetic polymers.	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply the knowledge of chemical reactivity to modify the biomolecules for practical use.	**K3**
CO2	Illustrate the chemical properties of the cross-linkers and design conjugated molecules for target specificity.	**K2**
CO3	Outline the methods used to modify the small molecules and biological macromolecules	**K2**
CO4	Apply the knowledge of bioconjugation techniques for use in industry, clinical care, and diagnosis	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	2	2								2
CO2	3	2										2
CO3	3	2										2
CO4	3	2	2	2								2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioconjugate Techniques	Hermanson, G.T.	3rd Edn., Academic Press, 2013.	2013
2	Chemistry of Bioconjugates: Synthesis, Characterization, and Biomedical Applications	Narain, R.	John Wiley UK 2014.	2014

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Bioconjugation Protocols: Strategies and Methods,	Mark S. S. (Ed.)	Volume 751 of Methods in Molecular Biology, 2nd Edn., Humana, 2016.	2016
2	Bioconjugation: Methods and Protocols: Volume 2033 of Methods in Molecular Biology 2033	Massa S., and Devoogdt N. (Eds.),	Springer New York, 2019	2019

SEMESTER S8

ADVANCED BIO SEPARATION ENGINEERING

Course Code	**PEBBT865**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. This course will allow students to recognize the basis for various steps in bio separations and their economics, to design a strategy for the purification of a product

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Selection of operations in separation processes:** Defining final product objective, characterization of starting material, selection of separation sequence, purification process and unit operations, selection of purification operations, protein purification and handling, use of protein properties in selection of purification operations. **Cell disruption methods:** Cell disruption by homogenizer-mechanism, process design considerations, enzyme release applications; Bead mill disruption-mechanism and design considerations, operational parameters and mixing characteristics; Enzymatic cell lysis and product release- Basic theory and models, methods and design, applications.	9
2	**Concentration and separation operations:** Membrane systems -Process description, theory of dialysis, reverse osmosis, ultrafiltration and crossflow filtration, batch continuous and diafiltration modes, applications**;** Ion-exchange processes- Physical description, separation mechanisms, equipment and applications, Aqueous-two phase separations- Theory,	9

	methods and applications, Precipitation- Theory, design/methods, applications.	
3	**Purification operations:** Ion-exchange in purification-Ion-exchange equilibria of biochemicals, chromatographic processes; Process affinity chromatography-Theoretical and practical considerations, affinity adsorbents, process affinity chromatography in operation, applications; Reversed-phase and hydrophobic interaction chromatography of peptides and proteins-Theory, applications, preparative separations; Electrically-driven separation processes-Analytical techniques, Theory of electrophoresis, modes of electrophoresis, sources of dispersion, continuous electrophoresis.	9
4	**Design of separation processes:** Synthesis of downstream processes-Separation processes involved, process synthesis, mathematical programming techniques, heuristics, artificial intelligence/expert systems, evolutionary methods; Downstream processing plant and equipment-Overview of bioprocess plants, downstream process equipment requirement, general factors affecting facility size and layout, DSP flowsheets; Downstream process economics- Commercialization and scaling-up of biotechnology, Case study-Production of human insulin using recombinant E. coli- Capital cost and operating cost estimation, return on investment-sensitivity analysis, cash flow analysis.	9

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the rationale for selection of operations for separation and purification of bio-products.	**K2**
CO2	Illustrate the design of various processes for cell disruption, concentration and purification of bio-products.	**K3**
CO3	Explain the design and scale-up of downstream process plant and equipment.	**K3**
CO4	Discuss the economics of downstream processing, in the back drop of suitable case studies.	**K3, K4**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											
CO2	3	3	3	2								
CO3	3	3	3	2								
CO4	3	3	3	2	3						3	

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Separation processes in Biotechnology	Juan A Asenjo	CRC Press	1st ed. 1990
2	Bioseparations Science and Engineering	Roger G Harrison, Paul Todd, Scott R Rudge, Demetri P Petrides	Oxford University Press	2nd ed. 2015
3	Bioseparations Engineering: principles, practice and economics	Michael R Ladisch	John Wiley and Sons	1st ed. 2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Handbook of Downstream Processing	Elliott Goldberg	Blackie Academic and Professional	1st ed. 1997
2	Engineering Processes for Bioseparations	Laurence R Weatherley	Elsevier	1st ed. 2013
3	Handbook of Bioseparations	Satinder Ahuja	Elsevier	1st ed. 2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	NPTEL: Principles of downstream techniques in bioprocesses https://youtu.be/jsVnQYxQDdk

SEMESTER S8

ENVIRONMENT MANAGEMENT SYSTEMS

Course Code	**OEBBT831**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	**Course Type**	Theory

Course Objectives:

1. To study environmental policies for sustainable development.
2. To create awareness to practice waste management through continuous improvement.
3. To develop practices that enables an organization to reduce its environmental impacts and increase its operating efficiency.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to environment Management (EM)- Goals of EM- EM tools, Ecosystem and its characteristics, Processes of Ecosystem- Biomass, Energy and energy flow, Policy and Legal Aspects of EM- Introduction to Environmental Policies, Environmental Policies and Programmes in India, Environmental Laws and Legislations, Environmental Legislations in India	**9**
2	Environmental Management System Standards, EMS Standards: ISO 14000, General overview, Implementation of EMS conforming to ISO 14001, Environmental management product design for the environment (ISO 14062), Product stewardship, principles of clean production, packaging, sustainable procurement, the social responsibility function of corporations, ecolabelling, ecological and carbon footprints (ISO 14064-6), Environmental management techniques, Ecosystem approach to risk assessment	**9**
3	Life Cycle Assessment (LCA), Stages in LCA of a Product, Procedures for LCA, Different Applications of Life Cycle Assessment (LCA), Environmental Auditing (EA), Elements of Audit Process, Waste Audits and	**9**

	Pollution Prevention Assessments, EA in Industrial Projects, Waste Audits and Pollution Prevention opportunities in Textile , Sugar, Pulp & Paper, Electroplating, Tanning industry, Dairy, Cement and Chemical industries, Liability Audits and Site Assessment, Auditing of EM.	
4	Environmental Design (ED) for Manufactured Products, ED for Developmental Planning, Environmental Economics, Economics and the Environment, Environmental valuation, Economics of Natural Resources, Ecological Economics, Applications of EMS.	**9**

Course Assessment Method
(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain Environmental Management Systems (EMS) and their main steps, relevant policies, other environmental management tools	**K2**
CO2	Summarize different environment management system standards	**K2**
CO3	Explain steps involved in environmental auditing and to make use of environmental auditing in various industries.	**K3**
CO4	Explain Environmental Design and environmental economics.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					3	3					
CO2	3					3	3					
CO3	3				2	3	3		2			
CO4	3					3	3					

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Environmental Management	Vijay Kulkarni and Ramachandra T.V	Commonwealth of Learning, Canada and Indian Institute of Science, Bangalore, Printed by TERI Press, New Delhi	2006
2	Environmental Management Systems	Christopher S. and Mark Y	Earthscan Publications, First South Asian Edition	2007, 3rd edition

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to Environmental Engineering and Science	Gilbert M.M.	Pearson Education	2004, 2nd edition
2	Environmental Planning and Management	Madu C.N.	Imperial College Press	2007
3	Environmental Management Strategies: The 21st Century Perspective	Gabriele Crognale	Prentice Hall Ptr Environmental Management Series,	Vol 5
4	Basic Concepts in Environmental Management	Kenneth M.M.	Boca Raton, FL, Lewis	1999
5	ISO 14000 Environmental Management	David L.G. and Stanley B.D.	Prentice Hal	2001

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/120/108/120108004/, https://onlinecourses.nptel.ac.in/noc22_ag10/preview
2	https://archive.nptel.ac.in/courses/120/108/120108004/, https://onlinecourses.nptel.ac.in/noc22_ag10/preview
3	https://archive.nptel.ac.in/courses/120/108/120108004/, https://onlinecourses.nptel.ac.in/noc22_ag10/preview
4	https://archive.nptel.ac.in/courses/120/108/120108004/, https://onlinecourses.nptel.ac.in/noc22_ag10/preview

SEMESTER S8

FUEL ENGINEERING

Course Code	OEBBT832	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To understand the atmospheric pollutants, standards, regulations, emission sources, and their fate.
2. To understand the fundamentals of atmospheric stability and air pollutant transport, characteristics of emission sources, and their control methods.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Global and Indian Energy production & consumption patterns and energy resources.Solid Fuels: Biomass, Wood, and Charcoal. Classification & Rank of Coal, Peat, Lignite, Sub-Bituminous coal, Bituminous coal, Anthracite coal, Cannel &Bog head coal. Physical Properties of coal, Proximate & Ultimate Analysis of Coal, Cleaning, washing & Storage of coal. Theory of coal Pyrolysis and Carbonization: Low-Temperature Carbonization(LTC), High-Temperature Carbonization(HTC), Properties of solid fuels.	9
2	Liquid fuels: Origin and classification of petroleum, crude exploration, petroleum refining processes, transportation, storage and handling of liquid fuels, properties & testing of petroleum products. Liquid fuel from coal: Bergius and Fischer Tropsch process. Other Synthetic Liquid fuels.(Benzol, shale oil, Gashol, power alcohol Colloidal fuel).	9
3	Gaseous fuels: Classification of gaseous fuel; Physico-chemical principles, Calorific Value, Wobbes index, and flame speed. Types of gaseous fuels:	9

	natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, cleaning and purification of gaseous fuels. Manufactured fuels: Agro fuels, Bio-Fuels: types of bio-fuels, production processes and technologies, biofuel applications.	
4	Combustion stoichiometry and thermodynamics, calculation of heat of combustion, theoretical & actual combustion processes - air-fuel ratio, estimation of dry and wet flue gases for known fuel composition, calculation of the composition of fuel & excess air supplied, flue gas analysis.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain energy resources, global and Indian energy production and consumption.	**K2**
CO2	Summarize the origin, classification, analysis, properties of solid fuels and their applications	**K2**
CO3	Explain the origin, classification, analysis, properties of liquid, fuels and their applications	**K2**
CO4	Explain the origin, classification, analysis, properties of gaseous and manufactured fuels and their applications. Outline basics of combustion stoichiometry and thermodynamics.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						3	3					3
CO2						3	3	3				3
CO3	2	3					3					2
CO4			3				3					2
CO5							3					3

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fuels & Combustion	Dr. Samir Sarkar	Orient Longmans	Third edition, 2009
2	"Modern Petroleum Technology", Vol. 1, Upstream	Dave, R.A.(Ed)	John Wiley and sons.	Sixth,2001
3	"Modern Petroleum Technology", Vol. 2, Downstream	Lucas, A.G. (Ed.)	John Wiley and sons.	Sixth,2002
4	"Combustion",	Glassman, I	Academic Press	Second,2014.

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	"Modern Petroleum Refining Processes"	Rao, B.K.B	Oxford & IBH Publishing Co. Pvt. Ltd	Fourth ,2018
2	Fundamentals of Renewable Energy Systems,	D. Mukherjee and S. Chakrabarti,	New Age International Publishers	First, 2004

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/105107213
2	https://nptel.ac.in/courses/105107213
3	https://nptel.ac.in/courses/105107213
4	https://nptel.ac.in/courses/105107213

SEMESTER S8

NANOMATERIALS AND NANOTECHNOLOGY

Course Code	**OEBBT833**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3: 0: 0: 0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	**Course Type**	Theory

Course Objectives:

1. Equip students with fundamental knowledge of the physics, chemistry, synthesis, and characterization of nanomaterials.
2. Enable the students with an understanding of the applications and potential of nanomaterials and nanotechnology for humankind.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Nanotechnology**: History of Nanotechnology, Pioneers in the field of nanotechnology. Classification of nano-materials - Zero-, one-, two- and three-dimensional nanostructured materials, Electromagnetic spectrum, particle size, and its significance. Physics of nanomaterials: Size effect on thermal, electrical, electronic, mechanical, optical, and magnetic properties of nanomaterials, surface area and aspect ratio, band gap energy, quantum confinement effect. Chemistry of nanomaterials-Ionic properties of nanomaterials. The electronic phenomenon in nanostructures. **Synthesis methods** - top-down and bottom-up approaches. Top-down approach – size reduction techniques like milling and machining. Bottom-up approach - Sol-gel methods, Chemical vapor deposition, Physical vapor deposition, Laser ablation methods.	9
2	**Synthesis, properties, and applications of nanomaterials**: Nanometals - gold and silver, different types of nano-oxides - Al_2O_3, TiO_2,	9

	ZnO and SiO_2. Special nanomaterials: synthesis, properties, and applications – fullerenes, graphite, graphene, carbon nano-tubes, nanowires, nanorods, nanofluids, nanoclusters, quantum dots. Nanocomposites - Matrix materials- Basics of the Metal matrix, Ceramic Matrix, and Polymer Matrix nanocomposites - Nano-reinforcements, nanofillers, and nanoclays.	
3	**Characterization techniques**: Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Probe Microscopy (SPM) - Scanning Tunneling Microscopy (STM) UV-visible spectroscopy, Raman spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), Dynamic Light Scattering (DLS), Thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC).	**9**
4	**Nanoelectronics:** Introduction to Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS), Nanomanipulation – STM-based atomic manipulations, Nanolithography, soft lithography, Scanning Probe Lithography, photolithography, E-beam Lithography, Focused ion beam lithography, Dip-pen Lithography. **Applications in energy and catalysis:** Applications (fundamental concepts only)Nanoscale advances in energy and catalysis - Nanotechnology for sustainable energy, nanotechnology-enabled renewable energy technologies. Application of nanomaterials in catalysis. **Applications in biotechnology**: (fundamental concepts only) - Nanomedicine, Drug delivery, Therapeutic applications, biosensors.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the basic principles of Physics and Chemistry and synthesis methods of Nanomaterials.	**K2**
CO2	Summarize the synthesis, properties, and applications of nanomaterials and nanocomposites.	**K2**
CO3	Outline various characterization techniques applied to nanomaterials.	**K2**
CO4	Explain the applications of nanotechnology in different fields of science and technology.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					2	2					2
CO2	3					2	2					2
CO3	3					2	2					2
CO4	3					2	2					2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	The Physics and Chemistry of Materials	Joel I. Gersten	Wiley	2001
2	Nano: The Essentials	T. Pradeep	McGraw-Hill (India) Pvt Limited	2008
3	Nanostructures & Nanomaterials: Synthesis, Properties & Applications	G. Cao. Y Wang	World Scientific	2011
4	Materials Characterization Techniques	S Zhang, L. Li and Ashok Kumar	CRC Press	2008
5	Nanocomposite science and technology	P. M. Ajayan, L. S. Schadler, P. V. Braun	Wiley-VCH	2005
6	Nanobiotechnology: Concepts, Applications and Perspectives	C. M. Niemeyer, C. A. Mirkin,	Wiley-VCH	2004
7	Nanotechnology and Nanoelectronics–Materials, Devices, Measurement Techniques	W. Fahrner	Springer-Verlag Berlin, Germany	2004
8	Surface Science: Foundations of Catalysis and Nanoscience	K.W. Kolasinski	John Wiley	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Nanomaterials: Synthesis, Properties and Applications	S. Edelstein and R. C. Cammarata	Taylor & Francis	1998
2	Physics and Chemistry of Nanostructured Materials	S.Yang and P.Shen	Taylor & Francis	2000
3	Characterization of Nanophase materials	Z L Wang (Ed.)	Wiley-VCH	2000
4	Nanofabrication, Principles, Capabilities and Limits,	Zheng Cui	Springer Science + business media, New York	2008
5	X-rays in Nanoscience - Spectroscopy, Spectromicroscopy, and Scattering Techniques	Guo, Jinghua (Ed.)	John Wiley	2010
6	Handbook of Nanoscience, Engineering and Technology,	William A. Goddard III (Ed), Donald Brenner (Ed), Sergey Edward Lyshevski (Ed), Gerald J Iafrate (Ed)	Kluwer publishers	2007
7	Bionanotechnology: Lessons from nature	David S Goodsell	John Wiley	2004
8	Textbook of Nanoscience and Nanotechnology	B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday	Springer	2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/113/104/113104102/
2	https://archive.nptel.ac.in/courses/118/102/118102003/ https://archive.nptel.ac.in/courses/118/107/118107015/
3	https://archive.nptel.ac.in/courses/102/104/102104069/
4	https://archive.nptel.ac.in/courses/112/107/112107283/ https://archive.nptel.ac.in/courses/118/107/118107015/

SEMESTER S8

FOOD PRODUCT DESIGN AND DEVELOPMENT

Course Code	**OEBBT834**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	Theory

Course Objectives:

1. This course enables the students to have an insight into the design, development, standardization, regulatory aspects, and commercialization of food products

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**New product development**: Introduction- new products, customers and consumers, value addition, and market. Marketing characteristics of new products-product life cycle and profit picture. Corporate avenues for growth and profitability, opportunities in the marketplace for new product development, technological advances driving new product development, and the government's role in new product development.	9
2	**Designing new products:** New Food Product Development (NPD) process and activities, NPD success factors, design thinking process, new product design, food innovation case studies, market-oriented NPD methodologies, the organization for successful NPD; Recipe development; use of traditional recipe and modification; involvement of consumers, chefs, and recipe experts; selection of materials/ingredients for specific purposes; modifications for production on a large scale, cost-effectiveness, nutritional needs or uniqueness; use of novel food ingredients and novel processing technologies.	9

3	**Standardization & Large-scale production:** Process and equipment design; manufacturing protocol, establishing process parameters for optimum quality; sensory evaluation; food testing lab requirements; different techniques and tests; statistical quality control; comparison of market samples; stages of the integration of market and sensory analysis.	**7**
4	**Quality, Safety & Regulatory aspects:** Product stability; evaluation of shelf life; changes in sensory attributes and effects of environmental conditions; accelerated shelf life determination; developing packaging systems for maximum stability and cost-effectiveness; regulatory aspects; approval for the proprietary product, food safety management system and quality audits for a food product, regulatory aspects of FSSAI for a food product **Advertisement, Marketing & Case studies:** Product performance testing; market positioning, Marketing: developing test market strategies; various tools and methodologies to evaluate consumer attitudes, preferences, and market acceptance factors; Case Studies - successes and failures, innovation, best practices, technological and marketing approaches to NPD; food choice models and new product trends	**11**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand food processing and nutrition in the development of a new product	**K2**
CO2	Develop a prototype, including a properly labeled package, for a new food product.	**K6**
CO3	Apply the appropriate processing technology to create a new product.	**K3**
CO4	Understand marketing and safety issues in Food Product Development	**K2**
CO5	Create a plan to deal with quality and safety issues	**K6**
CO6	Apply the knowledge of dietetics to develop new products	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3	2	2		2	2	2	2			2
CO3	3	3	2									2
CO4	3	3				2						2
CO5	3	3	2	2		2						2
CO6	3	3	2			2	2	2	2			2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Developing New Food Products for a Changing Marketplace	Brody, A. L., and John B. L.	2nd Edition, CRC Press, Taylor and Francis Group, UK, 2008.	2008
2	New Food Product Development: From Concept to Marketplace	Gordon W Fuller	3rd Edition, CRC Press, Taylor and Francis Group, UK, 2016.	2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Food Product Development: Based on Experience	Catherine Side.,	2nd Edition, Iowa State Press, Blackwell Publications, 2008	2008
2	Consumer-led Food Product Development	Macfie, H.,	1st Edition CRC press, Wood Head publications, 2007	2007

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc20_ag02/preview
2	https://onlinecourses.nptel.ac.in/noc23_ge32/preview
3	
4	

SEMESTER S8

ENTREPRENEURSHIP DEVELOPMENT IN BIOTECHNOLOGY

Course Code	**OEBBT835**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	Theory

Course Objectives:

1. This course enables the students to develop entrepreneurial skills in writing business plan market strategies and gain knowledge on patent filing and design

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to innovation and idea development:** Introduction to Innovation, managing innovation, types of innovation, creativity, the concept of design thinking, measuring innovation, Novelty -definition, identificationProtection of innovation - Introduction to Intellectual Property Rights – IPR, Patents, Trademarks, Copy Rights, grassroots innovation, Issues and Challenges in Commercialization of Technology Innovations. Concept of novelty and inventive steps in biotechnology. Patent laws related to microbial, pharmaceutical, environmental, and agricultural inventions, case studies in public health	9
2	**Entrepreneurship basics** – scope of entrepreneurship, characteristics of an entrepreneur, building a business, business plan, concept of lean canvas model, Entrepreneurship and Innovations, Converting Innovation to Economic Value - Growth Strategies, value proposition, Market Segments, Revenue Model, Social Entrepreneurship, Intrapreneurship, biotechnology entrepreneurship case studies.	9

3	**Technology product development-** Technology Life Cycle, how to implement and manage a technological innovation, new product development, managing the resources, technology business incubation, Sources of Information and schemes to support technology entrepreneurship, overview of the steps involved in the technology development in biotechnology.	**9**
4	**Functional areas of entrepreneurship -** marketing management, operations management, personnel management, financial management, procedure and formalities in setting up an Industrial unit, Problems for Small Scale Enterprises, and Industrial Sickness. Site visits to understand the Entrepreneurship activities of startups.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Build knowledge about Sources of Information and Support for Entrepreneurship	**K1**
CO2	Demonstrate the concept of Innovation, Intellectual Property Rights (IPR) and Technology Business Incubation	**K2**
CO3	Develop and strengthen entrepreneurial quality and motivation in students and impart basic entrepreneurial skills and understanding to run a business efficiently and effectively	**K6**
CO4	Evaluate new business opportunities in biotechnology	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3										2
CO2	3	3										2
CO3	3	3	2	2		2	2	2	2			2
CO4	3	3	2			2						2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Entrepreneurship	Hisrich R D, Peters M P	8th Edition, Tata McGraw-Hill, 2013	2013
2	Entrepreneurship: New Venture Creation	Holt David H	Pearson Education, 2016	2016
3	Entrepreneurship Development in India,	Debasish Biswas, Chanchal Dey,	Taylor & Francis	2021

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Entrepreneurship: Successfully launching new ventures,	Barringer, B. R.	Pearson Education	2015
2	Small-Scale Industries and Entrepreneurship	Desai, Vasant	Himalaya Publishing House, Delhi. 2008	2008
3	Entrepreneurship: Theory, Process, Practice.	Donald F. Kuratko,	Cengage Learning India, Delhi, 2017	2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/107/110107094/
2	
3	
4	

SEMESTER S8

WASTE TO ENERGY TECHNOLOGY

Course Code	OEBBT836	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NIL	Course Type	Theory

Course Objectives:

1. Develop a comprehensive understanding of various waste-to-energy technologies, including their principles, processes, and applications
2. Evaluate the effectiveness and feasibility of different waste-to-energy technologies in converting waste into usable energy.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Overview of Waste to Energy Technology:** Introduction to Waste to Energy Technology, Importance and benefits of Waste to Energy, Global and local perspectives on waste management and energy recovery. Types and Sources of Waste: Classification of waste (municipal, industrial, agricultural, etc.), Sources and characteristics of waste suitable for energy conversion, Waste collection, segregation, and preprocessing methods.	**9**
2	**Thermal Conversion Technologies:** ***Incineration:*** process, advantages, and disadvantages, Incineration technologies and their applications. ***Pyrolysis and Gasification:*** Pyrolysis: types, process, and applications, Gasification: principles, types, and benefits, Comparative analysis of pyrolysis and gasification	**9**
3	**Biological Conversion Technologies:** Overview of biological conversion technologies in WTE.	**9**

	Importance and role of biological conversion in waste management ***Anaerobic digestion***: process, types, and products, Technologies, and systems for anaerobic digestion. ***Fermentation and Composting***: Fermentation: ethanol production from waste, Composting, and other biological treatments, Comparative analysis of fermentation and composting	
4	**Chemical Conversion Technologies:** ***Transesterification***: Fundamentals of transesterification, Advantages, and challenges of transesterification, Chemical reactions involved, Catalysts used (acid, base, and enzyme catalysts). Biodiesel production from waste oils and fats: Raw materials and feedstock, Process flow and equipment. ***Hydrothermal processing***: Principles of hydrothermal processing, Supercritical water and its properties, Hydrothermal liquefaction (HTL) and hydrothermal carbonization (HTC) Conversion of wet waste to energy: Suitable feedstock and raw materials, Process flow, and equipment. Overview of emerging technologies in chemical conversion: Catalytic depolymerization, Plasma gasification, and Wet oxidation	**9**

Course Assessment Method
(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • A total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two 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. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Summarize the importance and benefits of various waste-to-energy technologies in global and local contexts.	**K2**
CO2	Utilize various thermal conversion technologies for waste-to-energy.	**K3**
CO3	Utilize various biological conversion technologies for waste-to-energy	**K3**
CO4	Apply chemical conversion technologies for waste-to-energy	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3		3							
CO2	3	3	3		3							
CO3	3	3	3		3							
CO4	3	3	3		3							

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Waste Recovery and Management	Ajay, Parveen, A. Kumar, R. K. Mittal, R. Goel	CRC Press	2023
2	Waste to Energy Conversion Technology	N. Klinghoffer, M. Castaldi	Woodhead Publishing Series in Energy,	2013.
3	Waste-to-Energy	M. J. Rogoff, F. Screve	William Andrew	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Waste-to-Energy Approaches Towards Zero Waste	C. M. Hussain, S. Singh, L. Goswami	Elsevier	2021
2	Up-to-Date Waste-to-Energy Approach	P. Stehlik	Springer	2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_ch29/preview
2	https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-ch09/
3	https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-ch09/

SEMESTER S8

NON-CONVENTIONAL ENERGY SYSTEMS

Course Code	**OEBBT837**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. To understand the importance and role of non-conventional energy systems in sustainable development.
2. To study various non-conventional energy sources and their technologies.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Non-Conventional Energy Systems:** Classification of Energy sources, Definition and importance of Non-Conventional Energy,Global and national energy scenario, Environmental impacts of conventional energy sources, Need for non-conventional energy sources. India's non-conventional sources. Solar Energy: Solar Radiation, Measurement, and estimation techniques, Solar Thermal Systems: Flat plate collectors, Concentrating collectors: Parabolic trough, dish, and solar tower. Applications: Solar water heaters, solar dryers, solar ponds. Solar Photovoltaic Systems: PV cell principles and materials (silicon, thin-film, organic), PV modules and arrays, solar farms, and off-grid systems. Solar Power Plants.	**10**

2	**Geothermal Energy:** Energy Conversion Systems, energy extraction principles: Hot water and dry steam systems. **Wind Energy:** Wind Characteristics and Measurement, Wind Energy Conversion Systems, horizontal and vertical axis windmills, performance characteristics, Wind Power Generation.	**8**
3	**Ocean Energy:** Ocean Energy Resources: Tidal energy, Wave energy, Ocean thermal energy. Tidal Energy Conversion Systems: Tidal barrages and tidal stream systems, Wave Energy Conversion Systems: Oscillating water columns, point absorbers, and overtopping devices, operation. Ocean Thermal Energy Conversion (OTEC): Working principles and types (closed-cycle, open-cycle, hybrid). **Energy from biomass:**: Principles of Bio-Conversion, Anaerobic /aerobic digestion, pyrolysis, gasification, anaerobic digestion (biogas production), Biodiesels: Manufacture and characteristics.	**9**
4	**Hydrogen Energy:** Hydrogen Production Methods: Electrolysis, Thermochemical processes. Storage and Transportation: Compressed gas, liquid hydrogen, metal hydrides. Safety and infrastructure. **Fuel Cells**: Working principle, types, Characterization and durability of fuel cells, Applications.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 subdivisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

At the end of the course, students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Classify various forms of Non-renewable and renewable energy and their importance.	**K2**
CO2	Explain solar energy and its technologies.	**K2**
CO3	Summarize Wind and Geothermal energy technologies	**K2**
CO4	Explain Ocean and Biomass energy technologies.	**K2**
CO5	Explain the principle of Hydrogen and Fuel cell technology.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3					3	3					
CO2	3					3	3					
CO3	3					3	3					
CO4	3					3	3					
CO5	3					3	3					

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Energy for a Sustainable World	Goldmberg J., Johansson, Reddy A.K.N. & Williams R.H.	John Wiley	
2	Renewable Energy Sources & Conversion Tech	Bansal N.K., Kleeman M. & Meliss M	Tata McGraw Hill	
3	Non-Conventional Energy Systems	Mittal K.M	Wheeler Pub	
4	Non-Conventional Energy Sources	Rai G.D	Khanna Pub.	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Chemical Technology	Venkataswarlu D	S. Chand	
2	Energy Technology	Rao S. & Parulekar B.B.	Khanna Pub.	
3	Solar Energy	Sukhatme S.P	Tata McGraw Hill	4th edition 2017

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1,2,3,4	https://onlinecourses.nptel.ac.in/noc22_ge14