Department of Bio-Engineering
Birla Institute of Technology, Mesra, Ranchi - 835215 (India)

Institute Vision

To become a Globally Recognized Academic Institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the National needs.

Institute Mission

- To educate students at Undergraduate, Post Graduate, Doctoral, and Post-Doctoral levels to perform challenging engineering and managerial jobs in industry.
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects.
- To develop effective teaching and learning skills and state of art research potential of the faculty.
- To build national capabilities in technology, education and research in emerging areas.
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society.

Department Vision

The Department of Bioengineering has a vision to impart international standard quality education in the field of Bioscience, Biotechnology and Bioengineering.

Department Mission

- To create state-of-the-art infrastructure for Research and Training in Biotechnology and Bioengineering.
- To provide globally acceptable technical education in Bioscience, Biotechnology and Bioengineering.
- To nurture graduates for innovation and creativity in the field of Bioscience, Biotechnology and Bioengineering having ethical and social concern.
- To promote collaboration with Academia, Industries and Research Organizations at National and International level to enhance quality of education and research.
- To contribute to socioeconomic development through education and bioentrepreneurship.

M.Tech (Biotechnology)

Programme Educational Objectives (PEOs)

PEO 1	Students will acquire necessary knowledge and skills in the frontier areas of Biotechnology.
PEO 2	Students will think critically and creatively about the use of biotechnology to address local and global problems.
PEO 3	Students will be able to implement the engineering principles to biological systems for development of industrial applications, as well as entrepreneurship skills to start biotech industries.

PROGRAM OUTCOMES (POs)

PO1:	An ability to independently carry out research /investigation and development work to solve practical problems.
PO2:	An ability to write and present a substantial technical report/document.
PO3:	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO4:	Recognise the need for continuous learning and will prepare oneself to create, select, learn and apply appropriate techniques, resources, and modern instrumentation to solve complex biotechnological activities with an understanding of the limitations.
PO5:	Demonstrate knowledge of biotechnology and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.
PO6:	Possess scientific or technological knowledge in one or more domains of Biotechnology and recognize opportunities and contribute to collaborative-multidisciplinary research, demonstrate a capacity for teamwork, decision-making based on open-mindedness and rational analysis in order to achieve common goals.

COURSE INFORMATION SHEET

Course code: BE501
Course title: ADVANCED BIOPROCESS ENGINEERING
Pre-requisite(s): B.E./B.Tech./M.Sc. in Biotechnology/Life Sciences
Co- requisite(s): None
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	State the enzyme kinetics, various factors regulating catalysis, different models for analyzing the enzyme kinetics, Immobilization and large-scale production of enzyme;
2.	Extend comprehensive knowledge about media constituents, formulations and microbial growth as well as measurement of cell biomass and analysis of mass balance, different methods of sterilization, agitation, oxygen transfer rate and operation of bioreactor;
3.	To demonstrate about concept and criteria of scale up of laboratory process, Instrumentation and process control- offline and online,
4.	Gain knowledge about the design of production of bioproducts under aerobic and anaerobic states, process economic and preparation of flow sheet of production process

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Explain the kinetics of enzyme catalysed reaction in free and immobilized states. They will also able to organise the production of microbial enzymes and operate variables affecting the production process.
CO2	Design medium for microbial growth, solve the mass balance of production process, propose and use the sterilizers for removal of microbial contaminants, state the significance of aeration and agitation for synthesis of bioproducts and modes of operation of Fermenter.
CO3	Collect the proficient knowledge of translation of lab data to pilot level, they will be able to solve features involved in the scale up process, process monitoring and control.
CO4	Develop the capacity of production processes and control of aerobic and anaerobic systems, solve calculation based on process economy as well as to recognize the importance of flow sheet of the production system.

Syllabus

Module I: Principles of Enzyme Catalysis:Introduction to enzymes, Mechanistic models for simple enzyme kinetics, rate parameters, Models for more complex enzyme kinetics, Effect of pH and temperature, Methods of immobilization, Diffusional limitations in immobilized enzyme systems, Brief introduction to large scale enzyme production. (8L)

Module II: Medium constituents, Designing of fermentation medium and its optimization. Improvement of industrially important microbes, Introduction to microbial growth and related kinetics, Factors affecting the growth, Mass balance, Stoichiometry, and Measurement of growth. (8L)

Module III: Bioreactors: Operation of bioreactors; Batch, Fed-batch and Continuous bioreactors, Immobilized bioreactor operation, Sterilization, Aeration, Agitation and types of impellers, Sparger, oxygen transfer in bioreactors and Power requirement. (8L)

Module IV: Scale up, Operation and Control of Bioreactors: Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control. (8L)

Module V: Industrial Processes and Process Economics:Description of industrial processes for bio-chemicals production, Process flow sheeting and Process economics. (8L)

Books recommended:

TEXT BOOK

1. Michael L. Shuler, FikretKargi, Bioprocess Engineering – Basic Concepts, 2nd Ed., Pearson Education India, 2015
2. James Bailey, David Ollis, Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill Education, 2017

REFERENCE BOOK

1. Roger G. Harrison, Paul W. Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, 2nd Ed., Oxford University Press, 2003.
2. Pauline M. Doran, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 2012

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus: **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.
POs met through topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	3	3	1	1
CO2	1	-	3	3	1	2
CO3	2	1	3	2	-	1
CO4	2	2	3	2	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BE 502
Course title: RECOMBINANT DNA TECHNOLOGY AND GENETIC ENGINEERING
Pre-requisite(s): Knowledge on Molecular Biology and Biochemistry
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: V
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	Introduce knowledge on basic concepts of molecular biology techniques
2.	Exemplify different types of polymerase chain reactions and their applications
3.	Implement, organize and design different vectors for gene cloning and expression
4.	Generating contextual and conditional knowledge of gene function for various applications

Course Outcomes

After the completion of this course, students will be able to:

CO1	Apply the principles of molecular biology techniques
CO2	Analyze the experimental data to select a suitable PCR for a particular application
CO3	Evaluate selectivity and specificity of vectors for cloning genes and their expressions.
CO4	Examine gene function, gene modulation and their effects on improvement of crops and animals.

SYLLABUS

Module I: Basics Concepts:Restriction and DNA modifying enzymes; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA using different techniques; Hybridization techniques: Southern, Northern, Colony and Fluorescence and *in situ* hybridization; Southwestern and Far-western cloning Chromatin Immunoprecipitation; DNA-Protein Interactions, Protein-protein interaction Metagenomics and its role in environment. (8L)

Module II: Cloning Vectors:Plasmids; Phagemids; EMBL Replacement vectors, Shuttle vectors; Cosmids; Yeast vectors, Artificial chromosomes (YACs, BACs); Animal Virus derived vectors, Plant based vectors, Transformation; Expression vectors (eukaryotic and prokaryotic); His-tag recombinant Protein purification, Construction of cDNA and genomic DNA libraries. (8L)

Module III:PCR and Sequencing Its Applications**:** Primer design; Fidelity of thermostable DNA polymerases; Types of PCR, T/A-vectors for cloning of PCR products; Quantitative Real Time PCR PCR in molecular diagnostics; Enzymatic DNA sequencing; Automated DNA sequencing; Next generation DNA sequencing techniques, RNA sequencing; Assembly and annotation of sequenced DNA (8L)

Module IV: Gene silencing techniques: Small double stranded RNAs; siRNA, Micro RNA; Artificial construction of siRNA vectors; Creation of knock out mutants in *C. elegans*, *Arabidopsis* and mice, Epigenetics, Genome Editing: CRISPR/Cas9 technology. (8L)

Module V: Applications of Genetic Engineering:Gene therapy, Gene replacement & Suicide gene therapy, DNA vaccine, Terminator technology, Golden rice, Safety guidelines of recombinant DNA research. (8L)

Books recommended:

TEXT BOOK

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006

REFERENCE BOOK

1. Technical Literatures from Thermo Scientific
2. Technical Literatures from Promega

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations
Gaps in the syllabus (to meet Industry/Profession requirements) Nil

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

POs met through Topics beyond syllabus/Advanced topics/Design**:** Nil

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,CD6,CD7
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BE503
Course title: ADVANCED REACTION ENGINEERING
Pre-requisite(s): Knowledge of Reaction engineering at UG level
Co- requisite(s): NIL
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course envisions imparting to students:

1.	To understand the basic principles of catalyzed and un-catalyzed heterogeneous reactions.
2.	To interpret through models to represent fluid-fluid and fluid-solid reactions and to design suitable reactor models
3.	To describe the kinetics of surface reactions; to evaluate mass and heat transfer phenomena and account for their impact on catalyst effectiveness
4.	To assess the principle causes of catalyst deactivation, regeneration
5.	To understand and analyse the heterogeneous reactions of biochemical systems

Course Outcomes

After the completion of this course, students will be able to:

CO1	Explain the mechanisms which occur in heterogeneous catalytic and non-catalytic reactors.
CO2	Recognise the rate limiting factor for catalytic and non-catalytic heterogeneous reactors. Analyse the biochemical heterogeneous systems.
CO3	Derive from first principles kinetic expressions and concentration profile expressions for catalytic and non-catalytic heterogeneous reactors.
CO4	Apply reactor models for the design and analysis of different reactor types.
CO5	Identify critical parameters affecting the performance of heterogeneous and multi-phase reactors; identify the critical parameters affecting the performance of catalyst

Syllabus

MODULE I: Introduction to Heterogeneous Reactions: Examples of heterogeneous reactions, Uncatalysed heterogeneous systems, Contacting pattern for two phase system, Kinetics of uncatalysed heterogeneous reactions, Problems. (8L)

MODULE II: Introduction to Catalyst and Catalytic Reactors: Types of Catalysts Characterizations, Physical properties of catalyst, surface area, void volume, solid density, pore volume distribution, Classification and preparation of catalysts, catalyst promoters, Catalyst inhibitors, Catalyst poisons, Nature and Mechanism of catalytic reactions, Catalysts Deactivation and Regeneration, Packed bed reactor, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors etc., Problems. (8L)

MODULE III: Solid Catalyzed Reactions: Introduction and Spectrum of kinetic regimes, Surface kinetics and rate equation, pore diffusion, porous catalyst, Heat effects, Performance Equation, Experimental methods and rate equation, Differential, integral, mixed batch and recycle reactors, determination of reactor size from rate equations. (8L)

MODULE IV: Kinetics and Design of Fluid- Fluid Reactions: The rate equation, Kinetic regimes for mass transfer and reaction, Fast reaction, Intermediate reaction, Slow Reactions, Factors to select the contactor, Straight mass transfer, Various cases of mass transfer with chemical reaction, reaction kinetics, Problems. (8L)

MODULE V: Heterogeneous Reactions in Bioprocessing: General Discussions on Heterogeneous Reactions in Bioprocessing, Concentration Gradients and Reaction Rates in Solid Catalysts, Internal Mass Transfer and Reaction, The Thiele Modulus and Effectiveness Factor, External Mass Transfer, Liquid–Solid Mass Transfer Correlations, Experimental Aspects, Minimising Mass Transfer Effects, Evaluating True Kinetic Parameters. Problems. (8L)

Text books:

1. Levenspiel, O., Chemical Reaction Engineering, 3rd Ed, Wiley, 2006
2. Gavhane, K.A., Chemical Reaction Engineering II, Nirali Publications, 2015
3. Pauline Doran, Bioprocess Engineering Principles, 2nd Ed, Academic Press, 2012

Reference books:

1. Foggler, H. S., Elements of Chemical Reaction Engineering, Prentice Hall of India, 2008.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)

Practical application of principles of heterogeneous catalysis w.r.t. Biochemical systems

POs met through Gaps in the Syllabus: **PO4 & PO5**

Topics beyond syllabus/Advanced topics/Design:

Biochemical catalysis

POs met through topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	-	1
CO2	1	-	3	3	2	2
CO3	2	1	3	2	-	1
CO4	2	2	3	2	2	2
CO5	1	2	3	1	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2,CD4,CD6, CD7
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: BE504
Course title: ADVANCED BIOPROCESS ENGINEERING LAB
Pre-requisite(s):
Co- requisite(s): BE 501
Credits: 2 L:0 T:0 P:4
Class schedule per week: 4
Class: M.Tech.
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course provides students to experimental exposure based on BE501 Advanced Bioprocess Engineering

Experiments

Experiment-1 Bioreactor parts and accessories
Experiment-2 Calibration of pH electrode and DO probe
Experiment-3 To prepare standard plot of protein
Experiment-4 To prepare standard plot of ammonia
Experiment-5 To prepare standard plot of sugar
Experiment-6 Growth of Bacteria/Yeast and mass balance: study in shake flask
Experiment-7 Growth of Bacteria/Yeast and O_2& rpm effectson it: study in fermenter/Bioreactor
Experiment-8 Immobilization of enzymes by entrapment
Experiment-9 Kinetic study of enzymes

Books recommended:

TEXT BOOK

3. Michael L. Shuler, FikretKargi, Bioprocess Engineering – Basic Concepts, 2nd Ed., Pearson Education India, 2015
4. James Bailey, David Ollis, Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill Education, 2017

REFERENCE BOOK

1. Roger G. Harrison, Paul W. Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, 2nd Ed., Oxford University Press, 2003.
2. Pauline M. Doran, Bioprocess Engineering Principles, 2nd Ed., Academic Press, 2012

Course Evaluation:
Individual Laboratory experiments, Quiz and Progressive and End semester examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Design of real-time industrial projects.
POs met through Gaps in the Syllabus: **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects.
POs met through topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	3	3	1	1
CO2	1	-	3	3	1	2
CO3	2	1	3	2	-	1
CO4	2	2	3	2	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD3, CD7
CO2	CD1,CD3, CD7
CO3	CD1,CD3, CD7
CO4	CD1,CD3, CD7

COURSE INFORMATION SHEET

Course code: BE 505
Course title: RECOMBINANT DNA TECHNOLOGY AND GENETIC ENGINEERING LAB
Pre-requisite(s): Knowledge on Molecular Biology and Biochemistry
Co- requisite(s): BE502 Recombinant DNA Technology and Genetic Engineering
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M. Tech
Semester / Level: I/5
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	Introduce knowledge on basic concepts of molecular biology techniques
2.	Exemplify different types of polymerase chain reactions and their applications
3.	Implement, organize and design different vectors for gene cloning and expression

Course Outcomes

After the completion of this course, students will be able to:

CO1	Apply the principles of molecular biology techniques
CO2	Analyze the experimental data to select a suitable PCR for a particular application
CO3	Evaluate selectivity and specificity of vectors for cloning genes and their expressions.
CO4	Examine gene function

SYLLABUS

Experiments:

1. Isolation of genomic DNA from plant leaves
2. Agarose gel electrophoresis of isolated genomic DNA
3. Isolation of total cellular RNA from plant leaves
4. Formaldehyde-agarose denaturating gel electrophoresis of RNA
5. Isolation of plasmid DNA from bacterial cultures and visualization on agarose gels
6. Spectrophotometric quantification and quality determination of isolated nucleic acids
7. Polymerase Chain Reaction based amplification of DNA
8. Real Time PCR based gene expression

9. Elution of DNA band from agarose gels
10. Ligation of eluted DNA to plasmid vectors for T/A based cloning
11. Preparation of culture media for transformation
12. Preparation of competent DH5α cells for transformation
13. Transformation of competent cells and plating
14. Selection of transformants based on blue-white colonies and evaluation of plasmids from transformed colonies

Books recommended:

1. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vol 1-3, Cold Spring Harbor Laboratory Press, 2001.
2. Technical Literatures from Thermo Scientific
3. Technical Literatures from Promega

Course Evaluation:
Quiz and End semester laboratory-based examinations

Gaps in the syllabus (to meet Industry/Profession requirements) Nil

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

POs met through Topics beyond syllabus/Advanced topics/Design: Nil

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	-	1
CO4	3	2	2	3	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD2, CD3
CO4	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course code: BE508
Course title: BIOPHYSICS
Pre-requisite(s):BE /B Tech Biotechnology/ Biochemical Engineering/ Chemical Engineering/ Food Technology or equivalent or M Sc Biotechnology/ Biochemistry/ Microbiology/ Plant Biotechnology/ Animal Biotechnology or equivalent.
Co- requisite(s): NIL
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	State students with concepts of spectroscopy, molecular imaging, molecular interactions
2.	Extend comprehensive knowledge of mathematical modelling of biophysical system;
3.	Illustrate basics of theory, parameters, power requirement and system controlling parts of various types' instrumental methods available in biological research/ biotechnology in industry and research lab (analytical techniques in spectroscopy, molecular imaging techniques).
4.	Enhance skills with application to solve problems onmembrane biophysics, electrical characteristics of cell, electrochemical potential, neuro-biophysics, use of radioactivity in biotechnology, electrophysiology and nuclear medicine.
5.	Design experiments to analyse biophysical activity in a system

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Demonstrate an understanding of the building blocks of basic and modern design and conduct experiments, as well as to analyze and interpret data for related to domain of Biophysics.
CO2	Ability to apply the knowledge of various types of industrially used spectroscopic and imaging methods; advantages and disadvantages, design criteria, molecular imaging,

	instrumentation and various aspects of operation.
CO3	Scrutinize processes of membrane biophysics, Bio-MEMS (design and application), Electrophysiology, Neuro-biophysics and Nuclear Medicine.
CO4	Assess an instruments or biophysical system for its stability, controllability, and observability properties

SYLLABUS

Module I: Biophysical basics: Vander-waals forces, Diffusion &Brownian Motion: diffusion eqn., Steady state two-dimensional diffusion, Molecular dynamics and Force-Fields. (8L)

Module II: Hydrodynamic and Bimolecular spectroscopy:Ultracentrifugation, Principle Instrument Designs& Applications and application in biology of IR/vibrational spectroscopy, Raman spectroscopy, Fluorescence spectroscopy (FRET), Nuclear Magnetic Resonance Spectroscopy and Massspectroscopy (8L)

Module III: Diffraction Techniques and Bioimaging:X-ray crystallography and Crystal Structure Analysis, Atomic Force Microscopy, Scanning & Transmission Electron Microscopy, Confocal Microscopy, Flowcytometry (FACS), Tomography imaging, Manipulation of bio-molecules using optical tweezers (optical trapping). (8L)

Module IV: Electrostatic interactions and Membrane Biophysics:Poisson-Boltzmann eqn. and its solution, Helix coil transition, Self-assembly, Relation between membrane potential & cell characteristics, Zeta, Stern & total electrochemical potential, Helmholtz-Smoluchowski equation, Trans-membranes potential & it's measurement by microelectrodes, Bio-MEMS (design and application). (8L)

Module V: Electrophysiology,Neurobiophysics and Nuclear Medicine: Action potential and its propagation, Voltage clamp and patch-clamp techniques, Electrocardiography (principle instruments and signal analysis), Electroencephalography, Basic principles of Nuclear Medicine, Diagnostic use of Radioisotopes In-vivo & In-vitro procedures. (8L)

Books recommended:

TEXT BOOK

1. Biological Physics (Updated Edition): Philip Nelson. 9780716798972. https://canvas.ucsc.edu/courses/1077/pages/useful-links.

REFERENCE BOOK

1. Introduction to Biophysics, Bert Kappen, (**R1**)

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :

Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design:

Bioelectronics

POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2		3	
CO2	3		1	3		1
CO3	3	1	2	1	2	3
CO4	3	2	2	2	2	2

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6
CO3	CD1, CD2, CD4,CD6,CD7
CO4	CD1, CD6,

COURSE INFORMATION SHEET

Course code: BE511
Course title: ENVIRONMENTAL BIOTECHNOLOGY
Pre-requisite(s): Basics in Microbiology, Molecular biology
Co- requisite(s):
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/5
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Identify and explain the environmental factors responsible for the pollution
2.	Provide solutions for environmental problems and understand legal aspects related with environmental issues and environmental protection
3.	Select the appropriate method for the treatment of wastewater and solid waste management
4.	Select and apply Suitable bioremediation methods for the treatment
5.	Recognise significance of biofuels and organic farming

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Identify the problems related to environment and the Environment Protection Acts and Legislations
CO2	Apply advanced knowledge on environmental waste management (waste water and solid waste)
CO3	Design techniques for bioremediation process
CO4	Identify and evaluate the importance of biofuels and organic farming
CO5	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

SYLLABUS

Module I: Introduction: Ecosystem, Concept of biosphere, Biodiversity and its conservation strategies, Sources of pollutants for Air, Water, Noise, Land; Pollution control and management-Environmental monitoring & sampling, Environmental Protection Acts and Legislations, National and international status, Environmental Planning for sustainable development (8L)

Module II: Waste Waterand Sludge Management: Modes of biological methods for waste water treatment, aerobic and anaerobic methods, activated sludge digestion process (8L)

Module III: Solid Waste Management: Solid waste-types and characteristics. Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic and hazardous waste (8L)

Module IV: Bioremediation: Types, microbial degradation and its mechanism, Bioaugmentation, Biosorption, Bioleaching, Phytoremediation, GMOs in waste management, Nanoscience in environmental management, Biosensors in pollution monitoring, Superbug(8L)

Module V: Biofuels and Organic Farming: Alternate Source of Energy, Biomass as a source of energy, Biomineralization, Liquid and gaseous biofuels, Microbial fuel cell, Biocomposting, Vermiculture, Biofertilizers, biopesticides (8L)

Books recommended:

TEXT BOOK

1. Dash and Dash, Fundamentals of ecology, 3rd Ed., TMH Education, 2009 (**T1**)
2. Mohapatra, Text Book of Environmental Biotechnology, 1st Ed.,I K International Publishing House Pvt. Ltd, 2007 (**T2**)
3. Peavy, Rowe, Tchobanoglous, Environmental Engineering, 1st Ed., McGraw Hill, 1984 (**T3**)

REFERENCE BOOK

1. Odum, Fundamentals of Ecology, 5th Ed., Brooks/Cole, 2004 (**R1**)
2. Metcalf and Reddy Inc et al, Wastewater Engineering: Treatment and Reuse, 4th Ed., McGrawHill Higher Education, 2002 (**R2**)

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

Mapping of Course Outcomes onto Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3	1	2
CO2	1	1	3	3	2	2
CO3	1	2	3	2	2	2
CO4	2	2	3	2	2	2
CO5	2	3	3	3	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2 and CD6
CO2	CD1, CD2 and CD6
CO3	CD1, CD2, CD5 and CD6
CO4	CD1, CD2, CD5 and CD6
CO5	CD1, CD2, CD4 and CD6

COURSE INFORMATION SHEET

Course code: BE512
Course title: MODERN METHODS OF INSTRUMENTATION
Pre-requisite(s): An adequate amount of knowledge in biology, Physics, Chemistry and instrumentation at graduate level. having an optimal knowledge on Structure of proteins, DNA, RNA, body metabolism.
Co- requisite(s): Nil
Credits: 3 L: 03 T:0 P:0
Class schedule per week: 03
Class: M. Tech
Semester / Level:I/5
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	An ability to demonstratethe basic science as well biotechnology knowledge of biotech industry in multidisciplinary teams and independently.
2.	develop the skills to understand the theory and practice of bioanalytical techniques
3.	Use scientific understanding of analytical techniques and detail interpretation of results.
4.	A master degree in this field prepares a student for careers in biotech research in different domains including industry.

Course Outcomes:

After the completion of this course, students will be:

CO1.	Able to use selected analytical techniques. Familiarity with working principals, tools and techniques of analytical techniques.
CO2.	Understand the strengths, limitations and creative use of techniques for problem solving.
CO3.	Develop expertise, an understanding of the range and theories of instrumental methods available in biological research/ biotechnology.
CO4.	Able to design bioanalytical techniques for quality control and product development, etc.

SYLLABUS

Module I: Chromatographic Techniques (a) Introduction to chromatography; General principles, column chromatography – columns, stationary phases. Partition and adsorption chromatography. (b) Affinity Chromatography; Principle, materials – matrix, selection of attachment of ligands, practical procedures, specific and non-specific elution, applications. (c) Ion Exchange Chromatography: Principle, types of exchangers, materials, choice of exchangers and buffers and applications. (8L)

Module II: Chromatographic Techniques: (a) Gas Chromatography: Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. (b) HPLC: Principle, components of HPLC system, pumping systems, detectors systems, and its applications; UPLC, determination of protein sequence and mass with LC-MS/MS and applications of MS in the analysis of drugs and macromolecules.: a case study. (8L)

Module III: Atomic spectrometry: Atomic absorption, X-ray fluorescence methods Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, ICP, X-ray fluorescence principle, Instrumentation, quantitative analysis. (8L)

Module IV: Electrophoresis: Gel electrophoresis; Types of gels, principle, apparatus and methods, gradient gels, Two-dimensional gels, isoelectric focusing, determination of molecular weight using electrophoresis, Case study. (8L)

Module V: Analytical and Imaging Instruments: Principle, instrumentation and application of FACS, FRET, cell on a chip, Thermogravimetry, fluorescence life time imaging (FLIM), Two photon and multiphoton microscopy. (8L)

Books Recommended:

TEXT BOOK

2. Skoog, D.A., Crouch, S.R., and Holler, F.J. “Principles of Instrumental Analysis”, 6th edition, Brooks/Cole, USA, 2006.
3. Williams, D. and Fleming, I. “Spectroscopic Methods in Organic Chemistry”, 6th edition, McGraw-Hill Higher Education, Maidenhead,UK, 2008.
4. Freifelder D., Willard and Merrit, Instrumental Methods and Analysis
5. Ewing GW, Instrumental Methods of Chemical analysis.

REFERENCE BOOK

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements) :
Students will be demonstrated on instruments with real samples, so that they can use the instruments.
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	1	3	-	-
CO2	3	-	1	3	-	1
CO3	3	1	2	3	2	1
CO4	3	2	2	3	2	2

<34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6
CO3	CD1, CD2, CD3,CD6
CO4	CD1, CD3,CD6
CO5	CD1,CD2,CD3,CD4,CD5

COURSE INFORMATION SHEET

Course code: BE513
Course title: ANIMAL CELL CULTURE
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: M.Tech.
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Impart the knowledge on basic tissue culture techniques.
2.	Be able to discuss the environmental and nutritional requirements for growing animal cells in culture
3.	Recognize the foundations of animal cell culture and explain the principles that form the basis for cloning and its application.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Demonstrate foundational knowledge of Cell culture techniques and competence in laboratory techniques.
CO2	Develop proficiency in establishing and maintaining of cell lines.
CO3	Explain the fundamental scientific principles that underlie cell culture.
CO4	Acquire knowledge in animal cloning and its applications.
CO5	Analyze a research problem and write clear, step-by-step instructions for conducting experiments or testing hypothesis.

SYLLABUS

Module I: Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures.Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence. (8L)

Module II: Cell Culture Lines: Definition, development and maintenance, cloning of cell lines, cell synchronization viral sensitivity of cell lines, cell line preservation and characterization, stem cell lines. (8L)

Module III: General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explantation technique. (8L)

Module IV: Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection, Organ Culture, whole embryo culture. (8L)

Module V: Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, Cloning for production of transgenic animals, cloning for conservation, *in-vitro* fertilization and embryo transfer. (8L)

Books recommended:

TEXT BOOK

1. Freshney, Animal cell culture – a practical approach**(T-1)**
2. N. Jenkins, Animal Cell Biotechnology: methods and protocols.**(T-2)**

REFERENCE BOOK

1. Masters, J. R.W., Animal Cell Culture, Oxford (2000) 3rd ed.**(R-1)**
2. Ranga, M.M., Animal Biotechnology, Agrobios (2007) 2nd ed. **(R-2)**

Course Evaluation:
Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):
Design of industry specific projects.
POs met through Gaps in the Syllabus:**PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:
Design optimization for industrial projects,Fractional order controller
POs met through Topics beyond syllabus/Advanced topics/Design: **PO5 & PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids

CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	-	1
CO2	3	1	1	1	1	3
CO3	3	3	2	3	-	1
CO4	3	2	3	2	2	2
CO5	3	3	3	3	3	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD2
CO3	CD1, CD2
CO4	CD1, CD2
CO5	CD1, CD2, CD3

COURSE INFORMATION SHEET

Course code: BE 514
Course title: CELL SIGNALLING AND ELECTROPHYSIOLOGY
Pre-requisite(s): B.E./B.Tech (any branch) with Basic on cell biology
Co- requisite(s): Basic Electrical and Electronics measurement
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Impart knowledge for interdisciplinary, applied engineering and technology.
2.	Understand basic cellular electrical characteristics.
3.	Learn and correlate the technicality associated with cell electrophysiology with electrical components and circuits.
4.	Record and analyse the electrophysiological characteristics of living system.

Course Outcomes:

At the end of the course, a student should be able to:

CO1	Define the generation of cell potentials.
CO2	Learn and apply the cellular electrical activities with basic electrical components.
CO3	Analyse the electrical model of generation and transmission of action potentials.
CO4	Evaluate the electrophysiological characteristics of living system.
CO5	Design and create a model of dynamics of receptor physiology in diseases.

Syllabus

Module I: Introduction to **c**ell signalling and pathways; Electrical and chemical signals in cellular communication. (8L)

Module II: The resting cell membrane; biophysics of excitable cells. Ionic basis of conduction; active and passive conductions; receptors, selectivity and recycling; generation and calculation of action potential. (8L)

Module III: Plant electrophysiology; Electrophysiological characteristics of plant cells; Extracellular and intracellular recording methods; Plant electrical responses to stresses. (8L)

Module IV: Electrophysiology of nerve and muscle cells; Types of synapses and neurotransmitters; chemical synapses and pattern of interconnections; synaptic transmission; biochemical control of synaptic transmission. Motor unit and surface electromyography, electroencephalography. (8L)

Module V: Generation of cardiac action potential; cardiac pacing system; maintenance of cardiac rhythmicity; electrocardiography; Reaction of neuron to injury; somatic receptor physiology of touch, pain and analgesia; electrophysiology of visual and auditory systems. (8L)

Text Book:

1. Principles of Neuroscience by E. R. Kandel and J. H. Schwartz, Elsevier, USA.
2. The Physiology of Excitable Cells by D. J. Aidley, Cambridge Press, UK.
3. Plant Electrophysiology Theory and Methods by Alexander G. Volkov (ed.), Springer.
4. Cell Signalling Biology by Michael J. Berridge, Portland Press Limited.
5. Textbook of Medical Physiology by A. C. Guyton, W.B. Saunders.
6. Computational Neuroscience:RrealisticModeling for Experimentalists; Ed: De Schutter, E. Boca Raton : CRC Press.
7. Foundations of Cellular Neurophysiology by D. Johnston, and S.M.S. Wu, MIT Press.

Reference Books:

1. Nerve, Muscle, and Synapse by B. Katz, Mc-Graw Hill press.
2. From Neuron to Brain by J.G. Nicholls, A.R. Martin & B. Wallace, Sinauer, Sunderland.
3. Electric Current Flow in Excitable Cells by J.J.B. Jack, D. Noble & R.W. Tsien, Oxford University Press.
4. Bioelectricity: A Quantitative Approach by R.D. Barr & R.L. Plonsey, Academic Press.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):

1. Design of real time projects to meet the research and industry requirements.
2. POs met through Gaps in the Syllabus:**PO3, PO6**

Topics beyond syllabus/Advanced topics/Design

1. Lecture on specialised techniques in electrophysiological recordings
2. Lecture on specialized electrophysiological devices
3. POs met through Topics beyond syllabus/Advanced topics/Design: **PO4, PO6**

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	2	-	-
CO2	3	2	1	-	3	-
CO3	-	-	3	-	2	3
CO4	1	2	-	-	2	2
CO5	-	-	3	-	2	3

< 34% = 1, 34-66% = 2, > 66% = 3

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1
CO3	CD1
CO4	CD1, CD3
CO5	CD1, CD2, CD3