BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI

NEW COURSE STRUCTURE - ***To be effective from academic session 2018- 19***

Based on CBCS & OBE model

Recommended scheme of study for M.Tech Programme in Biotechnology

Semester / Session of Study (Recomended)	**Level**	**Category of course**	**Course Code**	**Course**	**Mode of delivery & credits** *L-Lecture; T-Tutorial; P-Practicals*			**Total Credits** *C- Credits*
					L (*Periods/ week*)	**T (*Periods/ week*)**	**P (*Periods/ week*)**	**C**
	THEORY							
FIRST / Monsoon	**FIFTH**	Programme Core (PC)	BE501	Advanced Bioprocess Engineering	3	0	0	3
			BE502	r-DNA Tech. & Genetic Engineering	3	0	0	3
			BE503	Advanced Reaction Engineering	3	0	0	3
		Programme Elective (PE)		PE SUBJECT 1	3	0	0	3
		Open elective (OE)		OE SUBJECT 1	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	BE504	Bioprocess Engineering Lab	0	0	4	2
			BE505	r-DNA Technology Lab	0	0	4	2
		TOTAL						**19**
SECOND/ Spring	**FIFTH**	**THEORY**						
		Programme Core (PC)	BE506	Bioprocess Plant Design	3	0	0	3
			BE507	Advanced Bioseparation Engineering	3	0	0	3
			BE508	Biophysics	3	0	0	3
		Programme Elective (PE)		PE SUBJECT 2	3	0	0	3
		Open Elective (OE)		OE SUBJECT 2	3	0	0	3
		LABORATORIES						
		Programme Core (PC)	BE509	Bioprocess Plant Design Lab	0	0	4	2
			BE510	Bioseparation Engineering Lab	0	0	4	2
								19
TOTAL FOR FIFTH LEVEL								**38**
THIRD / Monsoon	**SIXTH**	**THEORY**						
		Programme Core (PC)	BE601	IPR, Biosafety & Bioethics	3	0	0	3
			BE600	Thesis Part I				8
		Programme Elective (PE)		Programme Elective 3	3	0	0	3
		LABORATORIES						
		Programme Core (PC)		(Based on Elecitve Specialization)	0	0	4	2
		TOTAL						**16**
FOURTH/ Spring		Programme Core (PC)	BE650	Thesis Part II				16
		TOTAL						**16**
TOTAL FOR SIXTH LEVEL								**32**
GRAND TOTAL FOR M.TECH PROGRAMME (38 + 32)								**70**

DEPARTMENT OF BIO-ENGG.
PROGRAMME ELECTIVES (PE) for M.Tech Biotechnology
OFFERED FOR LEVEL 5-6

PE / LEVEL	Code no.	Name of the PE courses	Prerequisites/Corequisites courses with code	L	T	P	C
Programme Elective -I							
PE/5 (MO)	BE511	Environmental Biotechnology	NIL	3	0	0	3
PE/5 (MO)	BE512	Modern Methods of Instrumentation	NIL	3	0	0	3
PE/5 (MO)	BE513	Animal Cell Culture	NIL	3	0	0	3
PE/5 (MO)	BE514	Cell signaling and Electrophysiology	NIL	3	0	0	3
Programme Elective - II							
PE/5 (SP)	BE515	Process Biotechnology	BE501	3	0	0	3
PE/5 (SP)	BE516	Stem Cells & Tissue Engineering	BE502	3	0	0	3
PE/5 (SP)	BE517	Protein Engineering	BE502	3	0	0	3
PE/5 (SP)	BE518	Biomedical Instrumentation	BE514	3	0	0	3
Programme Elective - III							
PE/6 (MO)	BE602	Advances in Nanobiotechnology	NIL	3	0	0	3
PE/6 (MO)	BE603	Metabolic Engineering	NIL	3	0	0	3
PE/6 (MO)	BE604	Biosimulation and Modelling	NIL	3	0	0	3
PE/6 (MO)	BE605	Neuromuscular Rehabilitation Engineering	NIL	3	0	0	3
PE/6 (MO)	BE606	Process Biotechnology Lab	BE515	3	0	0	3
PE/6 (MO)	BE607	Animal Cell Technology Lab	BE513	3	0	0	3
PE/6 (MO)	BE608	Biomedical Instrumentation Lab	BE518	3	0	0	3

*** PROGRAMME ELECTIVES TO BE OPTED ONLY BY THE DEPARTMENT STUDENTS**

DEPARTMENT OF BIO-ENGINEERING
OPEN ELECTIVES (OE)* FOR M.TECH/M.Pharm/M.Sc LEVEL
OFFERED FOR LEVEL 5-6

OE / LEVEL	Code no.	Name of the OE courses	Prerequisites/Corequisites courses with code	L	T	P	C
OE/5 (MO)	BE508	Biophysics	NIL	3	0	0	3
OE/5 (MO)	BE511	Environmental Biotechnology	NIL	3	0	0	3
OE/5 (MO)	BE514	Cell signalling and Electrophysiology	NIL	3	0	0	3
			NIL				
OE/5 (SP)	BE515	Process Biotechnology	NIL	3	0	0	3
OE/5 (SP)	BE516	Stem Cells & Tissue Engineering	NIL	3	0	0	3
OE/5 (SP)	BE518	Biomedical Instrumentation	NIL	3	0	0	3
OE/6 (MO)	BE602	Advanced Nanobiotechnology	NIL	3	0	0	3
OE/6 (MO)	BE604	Biosimulation and Modelling	NIL	3	0	0	3

*** OPEN ELECTIVES TO BE OPTED ONLY BY OTHER DEPARTMENT STUDENTS**

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.

Programme Educational Objectives (PEOs)- M.Tech (Biotechnology)

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)
M.Tech in Biotechnology

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.	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)

Text Books

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 Books

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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: I/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

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)

Text Books

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 Books

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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 to:

1.	Understand the basic principles of catalyzed and un-catalyzed heterogeneous reactions.
2.	Interpret through models to represent fluid-fluid and fluid-solid reactions and to design suitable reactor models
3.	Describe the kinetics of surface reactions; to evaluate mass and heat transfer phenomena and account for their impact on catalyst effectiveness
4.	Assess the principle causes of catalyst deactivation, regeneration
5.	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.

(9L)

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. (9L)

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.

(9L)

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.

(10L)

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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: Bioprocess Engineering Lab
Pre-requisite(s):
Co- requisite(s): BE 501 Advanced Bioprocess Engineering
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

Text Books

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 Books

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10
Day to day performance & Lab files	30
Viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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 Lab
Pre-requisite(s): Knowledge on Molecular Biology and Biochemistry
Co- requisite(s): Recombinant DNA Technology and Genetic Engineering (BE502)
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M. Tech
Semester / Level: I/05
Branch: Biotechnology
Name of Teacher:
Course Objectives

This course enables the students to:

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10
Day to day performance & Lab files	30
Viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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: BE 506
Course title: Bioprocess Plant Design
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: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Imparts advanced knowledge on bioreactor design for efficient utilization of the principles in bioprocess technology
2.	Acquire knowledge about materials of construction for bioprocess plants & mechanical design of process equipment and its economy
3.	Get details of instrumentation and control of bioprocesses
4.	Design of facilities for cleaning of process equipment

Course Outcomes

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

CO1	Have basic concepts of bioreactor design.
CO2	Detail out about materials used for construction of bioprocess plant reactors
CO3	Design of vessels for biotechnology application
CO4	Calculate and analyse process economics

Syllabus

Module-1: Introduction: Bottom line procedures of generalized bioprocess and design view, general design information; Possible milestones in a design project, process flow sheeting, review of mass and energy balance, Use of computer-aided process design and simulation packages. (8L)

Module-2: Piping & Instrumentation Diagram: General information of Piping and instrumentation for Bioprocessing; Materials of construction for bioprocess plants; piping details of size, length and type of valves and fittings, Mechanical design of process equipment. (8L)

Module-3: Design of Vessels for Biotechnology Application: Design of Upstream and Down Stream process equipments; fermenters, design considerations for maintaining sterility of process streams processing equipment; Selection and specification of equipment for handling fluids and solids; Selection and basic concepts of design of heat exchangers used in bioprocess industries.

(8L)

Module-4: Hazards and Safety: Design of facilities for cleaning of process equipment used in biochemical industries; Plant safety - the hazards procedures to overcome associated equipment design and operation; procedures to overcome hazards from safety point of views, Plant start-up safety review, safety aspects of the plant shut down procedures. Gantt chart (time schedule) with each steps of standard procedure of shut down of the plant.

(8L)

Module-5: Process Economics: Capital Cost Analysis, environmental protection and environmental impact analysis, Bioprocess validation. (8L)

Text Books:

1. Plant Design and Economics for Chemical Engineers, M. Peters and K. Timmerhaus, McGraw-Hill.
2. Applied Process Design for Chemical and Petrochemical Plants, E.E. Ludwig, Butterworth-Heinemann.
3. Paulin Doran, Bioprocess Engineering Principles. Ed 2, 2013, Elsevier

Reference Books:

1. Chemical Engineering, R.K. Sinnott, J.M. Coulson and J.F. Richardsons, Butterworth-Heinemann
2. Chemical Engineers Handbook, R.H. Perry and D.W. Green, McGraw-Hill
3. Manufacturing Facilities Design and Material Handling, F.E. Meyers and M.P. Stephens, Prentice Hall
4. Process Plant Layout and Piping Design, E. Bausbacher and R. Hunt, Prentice Hall PTR.
5. Fundamentals of Chemical Engineering, BezerBencho

6. Fermentation and Biochemical Engineering Handbook: Principles, process design and equipment, H. C.
7. Vogel,C.L. Todaro, C.C. Todaro, Hoyes data corporation/ Hoyes publications.

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

Gaps in the syllabus (to meet Industry/Profession requirements) : Nil
Topics beyond syllabus/Advanced topics/Design: Nil
POs met through topics beyond syllabus/Advanced topics/Design: **Nil**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	1	3	-	1	1
CO2	1	1	3	1	-	1
CO3	2	1	3	1	-	1
CO4	1	1	1	1	1	-

< 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, CD7
CO4	CD1, CD2,CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BE 507
Course title: Advanced Bioseparation Engineering
Pre-requisite(s): BE501 Advanced Bioprocess Engineering,
BE 503 Advanced Reaction Engineering
Co- requisite(s): BE506 Bioprocess Plant Design
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the basic principles in Downstream process
2.	Decide among different chromatography method for protein purification
3.	Separate a protein from a mixture
4.	Apply their knowledge to make crystals or dry powder of a bio-molecule

Course Outcomes

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

CO1.	Extract intra-cellular materials and separate bio-molecules
CO2.	Isolate a bio-molecule by adsorption, precipitation and extraction method
CO3.	Purify a protein using different chromatography techniques
CO4.	Separate molecules by various membrane based filtrations

CO5.	Perform crystallization and drying of a bio-molecule

SYLLABUS

MODULE-1: REMOVAL OF INSOLUBLE MATERIALS

An overview of Recovery processes, Removal of microbial cells and other solid matters from fermentation broth, Coagulation and Flocculation. Cell disruption techniques: Mechanical and non mechanical methods, Filtration and Centrifugation. (8L)

MODULE-2: ISOLATION OF BIOMOLECULES

Protein precipitation and separation; Aqueous-two-phase extraction; Supercritical extraction, Reverse micelles extraction; Adsorption-desorption process: isotherms. (8L)

MODULE-3: CHROMATOGRAPHIC TECHNIQUES

Principles and practice of liquid chromatography, gradient elution chromatography, ion-exchange chromatography, size exclusion chromatography, reversed phase chromatography, hydrophobic interaction chromatography, affinity chromatography; HPLC. (8L)

MODULE-4: MEMBRANE SEPARATION

Membrane materials and organization; Filter modules; Micro filtration, Ultra filtration; Reverse Osmosis, Electrodialysis, Advance membrane based separation process, e.g. Pervaporation, membrane bioreactor, membrane distillation etc. (8L)

MODULE-5: CRYSTALLIZATION AND DRYING

Crystallization: properties of a crystal, crystal growth and purity; Drying: different moisture content, drying kinetics, relative humidity, Industrial driers. (8L)

Text Books

1. Nooralabettu Krishna Prasad, Downstream Process Technology, 1st Ed., Phi learning Pvt. Ltd, New Delhi, 2010
2. B. Sivasankar, Bioseparations: Principles and Techniques, 1st Ed., Prentice Hall, 2005

3. Michael L. Shuler, Fikret Kargi, Bioprocess Engineering – Basic Concepts, 2nd Ed., Pearson Education India, 2015

Reference Books

1. Paul A. Belter, E. L. Cussler Wei-Shou Hu, Bioseparations: Downstream Processing for Biotechnology, Wiley India, Pvt Ltd., 1st Ed., 2011
2. James Bailey, David Ollis, Biochemical Engineering Fundamentals, 2nd Ed., McGraw Hill Education, 2017

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

Gaps in the syllabus (to meet Industry/Profession requirements):
Purification of non-protein bio molecules
POs met through Gaps in the Syllabus: **PO3**

Topics beyond syllabus/Advanced topics/Design:
Advance chromatographic separation processes
POs met through Topics beyond syllabus/Advanced topics/Design: PO3

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	2
CO2	3	-	1	3	-	2
CO3	3	1	2	1	2	2
CO4	3	2	2	2	2	3
CO5	3	-	2	1	-	-

< 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,CD5,CD6
CO4	CD1,CD2,CD5,CD6
CO5	CD1,CD2,CD6

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: II/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 modeling 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 on membrane biophysics, electrical characteristics ofcell, electrochemical potential, neurobiophysics, 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, Neurobiophysics and Nuclear Medicine.
CO4	Assess aninstruments 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)

Text Books

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

Reference Books

1. Introduction to Biophysics, Bert Kappen

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

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: BE509
Course title: Bioprocess Plant Design Lab
Pre-requisite(s): BE506 Bioprocess Plant Design
Co- requisite(s): NIL
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Imparts advanced knowledge on bioreactor design for efficient utilization of the principles in bioprocess technology
2.	Acquire knowledge about materials of construction for bioprocess plants & mechanical design of process equipment and its economy
3.	Get details of instrumentation and control of bioprocesses
4.	Design of facilities for cleaning of process equipment

Course Outcomes

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

CO1	Have basic concepts of bioreactor design.
CO2	Detail out about materials used for construction of bioprocess plant reactors
CO3	Design of vessels for biotechnology application
CO4	Calculate and analyse process economics

Experiment-1 Familiarization of software based process design.

Experiment-2 To design a complete flow diagram based on software of different bioprocesses with given inputs.

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

Gaps in the syllabus (to meet Industry/Profession requirements) : Nil
Topics beyond syllabus/Advanced topics/Design: Nil
POs met through topics beyond syllabus/Advanced topics/Design: **Nil**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10
Day to day performance & Lab files	30
Viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	1	3	-	1	1

CO2	1	1	3	1	-	1
CO3	2	1	3	1	-	1
CO4	1	1	1	1	1	-

< 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, CD7
CO4	CD1, CD2,CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BE510
Course title: Bioseparation Engineering Lab
Pre-requisite(s): BE507 Advanced Bioseparation Engineering
Co- requisite(s): NIL
Credits: 2 L:0 T:0 P:4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the basic principles in Downstream process
2.	Decide among different chromatography method for protein purification
3.	Separate a protein from a mixture
4.	Apply their knowledge to make crystals or dry powder of a bio-molecule

Course Outcomes

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

CO1.	Extract intra-cellular materials and separate bio-molecules
CO2.	Isolate a bio-molecule by adsorption, precipitation and extraction method
CO3.	Purify a protein using different chromatography techniques
CO4.	Separate molecules by various membrane based filtrations
CO5.	Perform crystallization and drying of a bio-molecule

List of Experiments

Experiment-1	To study the drying kinetics of tomato.
Experiment-2	Isolation of lycopene from tomato.
Experiment-3	Screening and selection of media for lipase production from a given bacteria.
Experiment-4	Precipitation of protein using ammonium sulphate salt.
Experiment-5	Quantitative estimation of protein by Bradford reagent.
Experiment-6	Bacterial cell lysis by sonication.
Experiment-7	Purification of protein by gel filtration chromatography.
Experiment-8	Separation and identification of protein in SDS-PAGE.
Experiment-9	Isolation of pigment from plant leaf using different solvents.
Experiment-10	Identification of different pigments separated by TLC.

Books Recommended:

1. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR, 2002
2. Doran, Bioprocess Engineering Principles, Academic Press, 1995
3. Bailey and Ollis, Biochemical Engineering Fundamentals, 1986
4. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.
5. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

Course Evaluation:

Individual lab performance, Theory (Quiz and End semester) examinations

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

Topics beyond syllabus/Advanced topics/Design: Nil

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10
Day to day performance & Lab files	30
Viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	2
CO2	3	-	1	3	-	2
CO3	3	1	2	1	2	2
CO4	3	2	2	2	2	3

CO5	3	-	2	1	-	-

< 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,CD5,CD6
CO4	CD1,CD2,CD5,CD6
CO5	CD1,CD2,CD6

COURSE INFORMATION SHEET

Course code: BE511
Course title: ENVIRONMENTAL BIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s):
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.	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 Water and 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)

Text Books

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

Reference Books

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

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	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):
Co- requisite(s): Nil
Credits: 3 L: 03 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.	An ability to demonstrate the 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.	To 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.	to be able to design bioanalytical techniques for quality control and product development, etc.

SYLLABUS

Module-1: Chromatographic Techniques-I

(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-2: Chromatographic Techniques-II

(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-3: 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-4: 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-5: 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)

Text Books

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

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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.	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 1: 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 2: 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 3: General Tissue Culture Techniques

Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explantation technique. (8L)

Module 4: 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. (7L)

Module 5: 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. (9L)

Text Books

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

Reference Books

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

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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: BE514
Course title: Cell Signalling and Electrophysiology
Pre-requisite(s):
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 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 1: INTRODUCTION TO CELL SIGNALLING
Introduction to **c**ell signalling and pathways; Electrical and chemical signals in cellular communication. (8L)

Module 2: MEMBRANE POTENTIAL
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 3: PLANT ELECTROPHYSIOLOGY
Plant electrophysiology; Electrophysiological characteristics of plant cells; Extracellular and intracellular recording methods; Plant electrical responses to stresses. (8L)

Module 4: ANIMAL ELECTROPHYSIOLOGY
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 5: ELECTROPHYSIOLOGY OF SPECIAL ORGANS
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 Books

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):

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

Topics beyond syllabus/Advanced topics/Design

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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

COURSE INFORMATION SHEET

Course code: BE 515
Course title: Process Biotechnology
Pre-requisite(s): BE 501Advanced Bioprocess Engineering
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: M. Tech
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the basic mechanism of bacterial growth, regulation of growth and mass balance
2.	Create awareness about various sources of industrial enzyme, production process with case study
3.	To learn the mechanism and significance of sterilization of growth medium and other accessories of fermenter
4.	Understand and identify the process of production of different primary metabolites with some examples
5.	Learn the production of secondary metabolites and their important roles

Course Outcomes

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

CO1.	Calculate kinetic parameters and yield from bacterial growth curve
CO 2.	Determine the effect of parameters on enzyme synthesis
CO 3.	Analyse the role of contaminants and their removal from production process
CO 4.	Evaluate and explore different primary and secondary metabolites

SYLLABUS

Module 1: Cell growth and kinetics
Pattern of growth behaviour in batch culture, role of media on growth processes, factors affecting the process of growth and model for Product formation, Mass balance, Yield prediction.
(8L)

Module 2: Enzyme Production
Introduction to industrial enzymes, optimization processes and regulation of production, large scale production of proteases, lipases and amylases etc., immobilization and related applications.
(8L)

Module 3: Sterilization
Importance of sterilization, design of sterilization process, introduction and the kinetics of death, various type of sterilization equipments, role of filters in fermentation process and sterilization of filters.
(8L)

Module 4: Production of primary metabolites
Bioprocesses for production of important primary metabolites - citric acid, lactic acid, glutamic acid ethanol, butanol, biomass utilization for synthesis of bio-chemicals. (8L)

Module 5: Production of secondary metabolites
Production processes of beta lactam antibiotics, penicillins and cephalosporins, semisynthetic penicillins, streptomycin, and vitamins (8L)

Text Books

1. Michael L. Shuler, Fikret Kargi, 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 Books

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):

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

Real time production process of different metabolites

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

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		2	3	1	1
CO2	1		3	3	3	2
CO3	2	1	3	2		3
CO4	2	2	2	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, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BE516
Course title: Stem Cells & Tissue Engineering
Pre-requisite(s): BE502 r-DNA Tech. & Genetic Engineering
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0 C: 3
Class schedule per week: 03
Class: M. Tech.
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables students to:

1.	Acquire knowledge on basics and clinical applications of stem cells technology
2.	Acquire knowledge on basics and clinical applications of tissue engineering
3.	Identify the steps and design experiments needed for an application in stem cells and tissue engineering
4.	Design and setup stem cell culture and tissue engineering laboratory

Course Outcomes

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

CO1.	Ability to understand the components of the tissue architecture
CO2.	Opportunity to get familiarized with the stem cell characteristics and their relevance in medicine
CO3.	Gain knowledge of induction and able to design the induction method for stem cells and tissue engineering research
CO4.	Awareness about the properties and broad applications of biomaterials used in stem cells and tissue engineering practices
CO5.	Overall exposure to the role of tissue engineering and stem cell therapy in organogenesis

SYLLABUS

Module-1:

Regulatory Mechanisms in Stem Cell: Transgene expression and RNA interference in Embryonic stem cells, lentiviral vector mediated gene delivery in human embryonic stem Cells. (8)

Module-2:

Organ Derived Stem Cells: Heart, Lung, Kidney, liver, adipose tissue, dental pulp, neural, mammary cell, skeletal muscle, spermatogonial cells etc. (8)

Module-3:

Stem Cell Induction: Mechanism of stem cells induction and applications. (8)

Module-4:

Industrial Approach to Stem Cell & Tissue Engineering: Stem cells and Tissue engineered products, bioreactors in stem cells and tissue engineering, cell delivery and recirculation, delivery of molecular agents in tissue engineering, stem cells in toxicology studies and as drug vehicles, case studies in tissue engineering. (8)

Module-5:

Laboratory Set-ups: Setting up stem cell culture and tissue engineering laboratory, hazards and precautions in stem cell storage and transplantation. (8)

Books Recommended

Text Books:

1. R. Lanza, J. Gearhart et al (Eds), Essential of Stem Cell Biology, 2009, Elsevier Academic press.
2. J. J. Mao, G. Vunjak-Novakovic et al (Eds), Translational Approaches In Tissue Engineering & Regenerative Medicine. (2008), Artech House, INC Publications.
3. N.A Habib, N Levicar, MY, Gordon, L., Jiao, and N. Fisk: Stem Cell Repair and Regeneration. Volume-2, 2007, Imperial College Press.
4. Palsson, B.O. and Bhatia, S., "Tissue Engineering", Pearson Prentice Hall, 2004.

Reference Books:

1. R. Lanza, I. Weissman, J. Thomson, and R. Pedersen: Handbook of Stem Cells, Two-Volume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult & Fetal Stem Cells, 2012, Academic Press.
2. Pallua, N. and Suscheck, C.V., "Tissue Engineering: From Lab to Clinic" Springer, 2010

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Advances in reproductive biology & Cloned animals

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

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
Direct Assessment

Assessment Tools	**% Contribution during CO Assessment**
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	**% Distribution**
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**
Continuous Internal Assessment				
Semester End Examination				

Indirect Assessment
1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
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	1	3	-	-	-
CO2	2	1	3	-	-	-
CO3	2	1	3	1	-	-
CO4	1	1	3	1	1	1
CO5	1	1	3	1	1	1

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE517
Course title: Protein Engineering
Pre-requisite(s): BE502 r-DNA Tech. & Genetic Engineering
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Understand about properties of protein, forces determining protein structure and folding pathways
2.	Learn about various techniques used to determine the detailed and most accurate 3D structure
3.	Impart knowledge about the protein denaturation and functionality of protein in grains, milk and egg and their responses with pressure, temperature and pressure
4.	Design and develop novel proteins using various recent approaches and to establish their industrial production

Course Outcomes

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

CO1.	Know detailed characteristics of protein and mechanism of protein folding
CO2.	Use various techniques for determining the most accurate 3D structure
CO3.	Gain knowledge about protein denaturation and functionality of protein at high pressure, temperature and pressure
CO4.	Engineer the novel proteins at industrial level for the production in therapeutics and health sector

SYLLABUS

Module-1:

Protein: Physicochemical properties of proteins, Forces determining the protein structure, Mechanisms of protein folding, molten globule structure, characterization of folding pathways.

(8L)

Module-2:

Protein Structure: Spectroscopic techniques for protein structure determination, Absorption and Fluorescence, Principle, methods and applications of Circular dichroism, FT-Raman, FT-IR, X-ray crystallography, NMR, MALLS.

(8L)

Module-3:

Protein Function: Principle and application of DSC, Protein denaturation, aggregation and gelation, Flow properties of proteins, Sensory properties of proteinaceous foods, Protein functionality in cereals, legume, oil seeds and pseudo cereals, Muscle protein, Milk protein, Egg protein

(8L)

Module-4:

Protein Modification: Role of technological processes like Thermal, Enzymatic, Physical, Pressure, Solvents and Interactions in protein modification, Effect of technological processes on nutritional value of food proteins.

(8L)

Module-5:

Protein Production: Design and construction of novel proteins and enzymes, Site directed mutagenesis for specific protein function and its production, Specific examples of protein engineering, Strategies for Industrial production of engineered proteins and their applications.

(8L)

Text books:

1. Carl, Branden and Tooze, John. Introduction to Protein Structure, Garland Publishing (Taylor and Francis Group). New York.
2. Yada, R. Y.; Jackman, R. L.; Smith, J. L. Protein Structure-Function Relationships Blakie Academic and Professional: London .

Reference books:

1. Clark, R. J. H and Hester, R. E. Spectroscopy of Biological Systems, John Wiley and Sons, New York
2. Nakai, S. and Modler, H. W. Food Proteins: Properties and Characterization, VCH Publishers, New York.

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 Outcome (CO) Attainment Assessment Tools and Evaluation Procedure
Direct Assessment

Assessment Tools	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 quizzes	30 (3×10)
Assignment(s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

Indirect Assessment
1. Student Feedback on Faculty
2. Student Feedback on Course

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments
CD3	Laboratory experiments/Teaching aids/Seminars
CD4	Mini Projects
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	1	3	1	1	2
CO2	3	1	1	2	2	2
CO3	2	2	3	1	3	1
CO4	1	1	3	1	2	1

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE518
Course title: Biomedical Instrumentation
Pre-requisite(s): Fundamentals of measurement system,
BE 514 Cell signaling and Electrophysiology
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: M. Tech
Semester / Level: II/05
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To impart knowledge for interdisciplinary, applied engineering and technology.
2.	With respect to design consideration, to understand the standard structure of biomedical instrumentation systems.
3.	To learn the technicality associated with instrumentation and design of basic biosignal and imaging equipment.
4.	To understand the engineering aspects for safety and hazards associated with biomedical instruments.

Course Outcomes

After the completion of this course, students will be:

CO1.	Understand the general physiology for man-machine interaction in medical environment.
CO2.	Understand the fundamentals of the concept and design of biomedical equipment.
CO3.	Understand the importance of medical data transmission for better healthcare.
CO4.	Analyse the electrical hazards associated with medical equipment so that the safety equipment can be devised or suggested.
CO5.	Work in an interdisciplinary team.

SYLLABUS

Module 1: General Physiology

Physiology of cardiac system, pulmonary system, urinary system, nervous system, muscle and special sense organs. Generation and propagation of action potentials in muscle, heart and nervous system.

(8L)

Module 2: Bio-Signal Devices

Electrocardiograph; Electromyograph; Electroencephalograph; Electrogastrograph; Electrooculograph; Phonocardiograph; Plethysmograph; Pulmonary function test devices; Non-Invasive and Invasive Blood Pressure measurement; Holter recorder; Stress test.

(8L)

Module 3: Assistive, Therapeutic and Surgical Devices

Pacemaker; Defibrillator; Anesthesia machine; Ventilator; Heart-Lung machine; Therapeutic and Surgical diathermies; Nerve and Muscle stimulators; Patient Monitoring System; Micro and Macro Electrical Shock Hazards.

(8L)

Module 4: Anatomical and Physiological Imaging

Generation of X-ray; X-ray imaging device; Catheterization system; Computer Assisted Tomography. Nuclear Magnetic Resonance; Magnetic Resonance Imaging device; Generation and properties of ultrasound; Ultrasound and Doppler equipment. Functional imaging with Gamma camera; Single Photon Emission Tomography and Positron Emission Tomography.

(8L)

Module 5: Biomedical Safety

Need of sterilization; Autoclave; Ethylene Trioxide sterilizer; Ultrasonic and Microwave based sterilization. Ionic and Non-Ionic Radiation hazards; Protection from radiation; Radiation measuring devices.

(8L)

Text Books:

1. Textbook of Medical Physiology by A. C. Guyton, 8th edition, Prism Indian Publication, Bangalore, 1991.
2. Handbook for Biomedical instrumentation by R. S. Khandpur, 3rd edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014.

Reference Books:

1. Biomedical Engineering and Instrumentation, Basic Concepts and Applications by J. D. Bronzino, 1st Edison, PWS Publishers, Boston, 1986.
2. Medical instrumentation, Application & Design by J. G. Webstar, 4th edition, Wiley Student Edition, New Delhi, 2009.
3. Introduction to Biomedical Equipment Technology by J. J. Kar and J. M. Brown, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016.

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

POs met through Gaps in the Syllabus
Conducting presentations in group and writing reports.
Giving assignments to the students on some relevant topics.
Industrial visits.
POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design

Lecture on brain-computer interaction and specialized imaging devices.
POs met through Topics beyond syllabus/Advanced topics/Design are: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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		2	3		2
CO2			2	3		2
CO3	1		1	2		2
CO4		2	2	3		3
CO5	1	1			2	2

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

Mapping Between COs and Course Delivery (CD) methods

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

COURSE INFORMATION SHEET

Course code: BE600
Course title: Thesis Part I
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 8 L: T: P:
Class schedule per week:
Class: M.Tech.
Semester / Level: III/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Solve real world problems and challenges
2.	Solve the various research challenges in the field of Biochnology
3.	Create awareness among the students of the characteristics of several domain areas where their project ideas could help humanity
4.	Improve the team building, communication and management skills of the students

Course Outcomes

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

CO1.	Demonstrate a sound technical knowledge of their selected project topic
CO 2.	Undertake problem identification, formulation and solution
CO 3.	Design biotechnological solutions to complex problems utilizing a systems approach
CO 4.	Communicate with scientists/engineers and the community at large in written and oral forms
CO5	Demonstrate the knowledge, skills and attitudes of a professional biotechnologist.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

COURSE INFORMATION SHEET

Course code: BE601
Course title: IPR, Biosafety & Bioethics
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: III/06
Branch: Bioengineering
Name of Teacher:

Course Objectives
This course enables the students to:

1.	Create awareness on IPR issues and need for knowledge in patents in biotechnology
2.	Understand the biosafety regulations and ethical practices in biotechnology
3.	Familiarize with the ethical practices in biotechnology

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

CO1	Understand and follow the regulatory framework important for the product safety and benefit for the society.
CO2	Devise business strategies by taking account of IPRs
CO3	Acquire adequate knowledge in the use of genetically modified organisms and its effect on human health
CO4	Gain more insights into the regulatory affairs.

SYLLABUS

Module-1: Introduction to Intellectual Property

Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Agreements and Treaties; Indian Patent Act 1970 & recent amendments.

(8L)

Module-2: Basics of Patents and Concept of Prior Art

Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art"; Patent databases. (8L)

Module-3: Patent Filing Procedures

National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting–disclosure/non-disclosure; Financial assistance for patenting-introduction to existing schemes, Patent licensing and agreement Patent infringement-meaning, scope, litigation, case studies.

(8L)

Module-4: Biosafety

Introduction to Biological Safety Cabinets; Biosafety Levels; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines: Government of India; GMOs & LMOs; Roles of Institutional Biosafety Committee, Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements, Cartegana Protocol. (8L)

Module-5: Bioethics

Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.

(8L)

Text books:

1. Deepa Goel & Shomini Parashar IPR, Biosafety and Bioethics
2. Anupam Singh Intellectual Property Rights and Bio-Technology Biosafety and Bioethics

Reference books:

1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

Real time production process of different metabolites

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

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	2	2	3	1	1
CO2	1	1	3	3	3	2
CO3	2	1	3	2	3	2
CO4	2	2	2	2	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, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,

COURSE INFORMATION SHEET

Course code: BE602
Course title: Advanced Nanobiotechnology
Pre-requisite(s):
Co- requisite(s): NIL
Credits: 3 L:03 T:0 P:0
Class schedule per week: 03
Class: M. Tech
Semester / Level: III/06
Branch: Bioengineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Provide an insight into the essentials of nanotechnology in biological and biomedical research
2.	Familiarize the students with nanomaterials type and their selection for for a diversity of analytical and medicinal rationales
3.	Gain a working knowledge of different nanotechnology techniques and acquire the ability to use them to solve problems in bioengineering, biomedicine and agricultural/environmental issues.
4.	Gain detail understanding of biological interactions of nanomaterials and apply concept in designing nano-bio systems/devices in global, economic, environmental, and societal context.
5.	Learn the wide range of applications of nanotechnology and its interdisciplinary aspect. Ability to identify career paths at the interface of nanotechnology, biology, environmental and agricultural engineering and medicine.

Course Outcomes

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

CO1.	Understand the fundamentals of nanoscience, nanotechnology and biology with detail knowledge of different nanomaterial types and properties
CO2.	Acquire the knowledge on different nanofabarication methods, their impact in global, economic, environmental, and societal context. Skilled in various characterization techniques.
CO3.	Recognize and relate to the structural and functional principles of biomolecules-nanomaterials interactions and their significance in designing nanomaterials and nanodevices

CO4.	Familiarize themselves with nanobiotechnology potentialities and concerns associated with nanomaterials usage and handling. Able to apprehend and explain use of nanomaterials in different medical/environmental applications.

SYLLABUS

Module 1: **Introduction to Nanobiotechnology**
Nanoscale effect & properties, fundamental phenomena as a function of size and reduced dimensionality, types of nanomaterials (metal, quantum dots, polymer nanoparticles, carbon nanotubes, dendrimers) (8 L)

Module 2: Nano-Materials synthesis & Characterization
Nanofabrication methods: Top-Down approaches, Bottom-Up approach, Biological approach, Nanoscale visualization & characterization techniques (8 L)

Module 3: DNA & Protein based Nanostructures
DNA–Protein Nanostructures, DNA–Gold-Nanoparticle Conjugates, Nanomotors, S-Layers (8 L)

Module 4: **Emerging Nanobiotechnologies**
Miniaturized devices in nanobiotechnology - types and applications, microfluidic meet nano: lab on a chip concept, biosensors, nanobiosensors, nanolabels (8 L)

Module 5: Nanomaterials application & Future Challenges
Bioimaging, Drug Delivery, Cancer nanotechnology, Hyperthermia, regenerative therapy, industrial nanotechnology, Nanotoxicity & challenges ahead (8 L)

Text books:

1. Niemeyer and Mirkin ed. Nanobiotechnology: concepts, applications & perspectives,
2. Jain, KK. Nanobiotechnology in molecular diagnostics: current techniques and applications

Reference books:

1. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012

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

Gaps in the syllabus (to meet Industry/Profession requirements) :
High end characterization techniques (TEM/HRTEM)
POs met through Gaps in the Syllabus: **PO4**

Topics beyond syllabus/Advanced topics/Design:
Advance nanomaterials
POs met through Topics beyond syllabus/Advanced topics/Design: **PO4**

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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 Objectives and Program Outcomes

Mapping of Course Outcomes and Program Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	-	-	-	3
CO2	3	-	1	2	-	-
CO3	2	-	-	3	-	-
CO4	-	1	-	2	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, CD2
CO4	CD1,CD2, CD8

COURSE INFORMATION SHEET

Course code: BE603
Course title: Metabolic Engineering
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: 3 L:03 T:0 P:0
Class schedule per week: 03
Class: M. Tech
Semester / Level: III/06
Branch: Bioengineering
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand about cellular metabolism, their coordination and regulation
2.	Get knowledge about metabolic kinetics, mass balances and metabolic regulation identifications
3.	Impart knowledge about the programming and cell capability and metabolic flux analysis
4.	Establish an understanding about metabolic control and pathways analysis, modelling and various application

Course Outcomes

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

CO1.	Understand about detailed cellular metabolism, coordination and their regulation
CO2.	Know about kinetics and mass balances for transient cases, flux analysis as well as feed-back regulation
CO3.	Able to understand about various pathways involved in metabolic control analysis
CO4.	Design different models and algorithm as well as understand about detailed application

SYLLABUS

Module-1:

Cellular Metabolism: Overview of cellular metabolism, Fueling Metabolism, Supply of biomass precursors, Anabolism and anaplerosis, Coordination of metabolic reactions, Metabolic regulation network at enzyme level and whole cell level, metabolic strategies and regulation, methods employed to study metabolism and pathway analysis, Integration of metabolic pathways

(8L)

Module-2:

Metabolic Networks: Kinetics, mass balances for the steady state, mass balances for the transient case, Metabolic regulation identification, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feed-back regulation, Energy changes and multi gene network.

(8L)

Module-3:

Metabolic Flux Analysis: Linear programming, Cell capability analysis, Genome scale, Isotope labeling, Experimental determination method of flux distribution, Metabolic flux analysis and its applications,

(8L)

Module-4:

Metabolic Control Analysis: Determination of flux control coefficient, Metabolic control analysis in linear and branched pathways, Analysis of metabolic control and the structure

(8L)

Module-5:

Metabolic Network Design: Integer programming, Mixed-integer nonlinear programming, Metabolic pathway modeling, Metabolic networks, Metabolic pathway synthesis algorithms, Application in pharmaceuticals, Chemical bioprocess, Food technology, Agriculture, Environmental bioremediation and Biomass conversion.

(8L)

Text Book:

1. Metabolic Engineering: Principles and Methodologies. Edited by G. Stephanopoulos, A. Aristidou, J. Neilson. (1998) Academic Press, San Diego, CA.
2. Metabolic Engineering Edited by S. Y. Lee & E.T. Papoutsakis (1999) Marcel Dekker, New York, pp.423.

Reference Books:

1. Biochemistry by J. M. Berg, J. L. Tymoczko and LubertStryer (2002) Fifth Edition, W.H. Freeman, New York.
2. Understanding the Control of Metabolism by David Fell (1997) Portland Press, London,.
3. Metabolism at a Glance by J. G Salway (1994) Blackwell Scientific Publications, Oxford,.
4. Systems Biology: Properties of Reconstructed Networks. B. O. Palsson, Cambridge University Press, 2006.

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

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	2	2	2	1	2
CO2	1	1	2	2	3	2
CO3	2	1	1	3	2	3
CO4	2	2	1	2	1	3

< 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,

COURSE INFORMATION SHEET

Course code: BE604
Course title: Biosimulation and Modelling
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L:03 T:0 P:0
Class schedule per week: 03
Class: M. Tech
Semester / Level: III/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understanding of basic design principles of biosystem, bioprocess and bioreactors
2.	Acquire knowledge on mathematical and engineering concepts about operational modellings and related simulations for bioprocess, process equipment and its economy
3.	Design and applications of specialized simulation softwares for bioprocess development

Course Outcomes

After the completion of this course, students will be:

CO1.	Analyse the biological and bioprocess data and make suitable interpretation of them
CO2.	Handle mathematical models and simulation softwares for bioprocess development

SYLLABUS

Module-1:

Modelling Principles: Basic modeling principles, uses of mathematical modeling classification of modeling techniques Fundamental laws, energy equations, continuity equation, equations of motion, transport equations, equations of state, equilibrium states and chemical kinetics-examples.

(8L)

Module-2:

Mathematical Models for Biochemical Engineering Systems: Mathematical models for Biochemical engineering systems, Mathematical models in batch and continuous process, continuous flow tanks, reversible reaction.

(8L)

Module-3:

Simulation Softwares in Bioprocess: Introduction to SuperPro Designer for Material balance, Software for mass and energy balance; Energy Balance with and without reaction.

(8L)

Module-4:

Metabolic Flux Balance Analysis: Introduction, Principle of steady state metabolic flux balance analysis, COPASI, COBRA.

(8L)

Module-5:

Matlab and Simulink: MATLAB for data analysis Basics, Data analysis, curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Simulation of gravity flow tank, SIMULINK for dynamic systems.

(8L)

TEXT BOOKS

1. Luben W.L. "Process Modelling Simulation and Control for Chemical Engineers", McGrawHill, International New York, 1990.
2. Franks RGE. "Mathematical Modeling in Chemical Engineering", John Wiley and Sons, Inc., New York, 2004.
3. Biquette W.B. "Process Dynamics- Modeling analysis with simulation", Prentice Hall; 1 edition January 15, 1998.
4. William J. Palm. "Introduction to Matlab 7 for Engineers", III, McGraw Hill 2005.

REFERENCE BOOKS

1. Kenneth J. Beers. "Numerical Methods for Chemical Engineering Applications in MATLAB", Massachusetts Institute of Technology, Cambridge University press 2007 edition.
2. http://www.mathworks.com

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

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 OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Assessment Components	CO1	CO2	CO3	CO4
Continuous Internal Assessment				
Semester End Examination				

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	1	1	1
CO2	2	2	3	2	1	1

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE605
Course title: Neuro-Muscular Rehabilitation Engineering
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: III/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Impart knowledge for interdisciplinary, applied engineering and technology.
2.	With respect to design consideration, to understand the sensory physiology of human system.
3.	Learn the technicality associated with instrumentation and design of basic rehabilitation system.
4.	Understand the engineering aspects for challenges in designing a rehabilitation system.

Course Outcomes

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

CO1.	Understand the sensory physiology in nerve-motor communication system.
CO2.	Learn and remember the fundamentals on rehabilitation science, engineering and technology.
CO3.	Analyse the instrumentation requirements of rehabilitation system.
CO4.	Evaluate the challenges in designing support device.
CO5.	Designing of a system to augment disabilities.

SYLLABUS

Module 1: Fundamentals of Rehabilitation Engineering

Introduction, rehabilitation science, technology and engineering, rehabilitation engineering in sensory, motor and communication system; measurement tool and process in rehabilitation engineering, Sensory-Motor augmentation; Stroke and Stroke Rehabilitation; Approaches in Human-Computer Interfaces.

(8L)

Module 2: Neuromuscular Assessment

Gait and motion analysis, Electromyography (EMG) techniques: Signal generation from muscles and its conditioning, single and multichannel EMG; Compound muscle action potential and motor nerve conduction; Assessments of nerve conduction for neurophysiological analysis; Muscle Cartography; Myoelectric manifestation of muscle fatigue.

(8L)

Module 3: Sensory Rehabilitation

Speech, Language and Swallowing Disorders; Techniques in tactile rehabilitation, Assistive technology in hearing: Pure tone audiometry, immittance audiometry; Electric response audiometry; audiometric equipment design and calibration; Different types of electronic hearing aids.

(8L)

Module 4: Assistive Technology in Vision

Visual activity measurement, field of vision test, pressure measurement, biometry, optical coherence tomography; ocular electrophysiology; Haptics as a substitute of vision; Mobility aids for visually impaired.

(8L)

Module 5: Challenges in Rehabilitation Engineering

Designing of rehabilitation system: Behavioral and learning problems in disabled; Sociolegal aspects of Rehabilitation.

(8L)

Text Books

1. Assistive Technology for Visually Impaired and Blind People by Marion A. Hersh and Michael A. Johnson (Eds.), Springer
2. Assistive Technology for the Hearing-impaired, Deaf and Deafblind by Marion A. Hersh, Michael A. Johnson (Eds.), Springer
3. Textbook of Rehabilitation by S. Sunder, Jaypee Medical Publications, New Delhi.
4. Acquired Brain Injury-An Integrative Neuro-Rehabilitation Approach, Jean Elbaum Deborah M. Benson (Eds.), Springer.
5. Electromyography (Physiology, Engineering, and Noninvasive Applications) by Roberto Merletti and Philip Parker (Eds.), IEEE Press, John Wiley & Sons Inc. Publication

Reference Book

1. Biomedical Engineering Handbook by J. D. Bronzino, CRC Press

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

POs met through Gaps in the Syllabus

Conducting presentations in group and writing reports
Giving assignments to the students on some relevant topics
POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design :

Lecture on special sensory organs

POs met through Topics beyond syllabus/Advanced topics/Design are: PO3

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	50
Semester End Examination	50

Continuous Internal Assessment	% Distribution
3 Quizzes	30 % (3 × 10%)
Assignment (s)	10
Seminar before a committee	10

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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		2			3
CO2	1	2		3		3
CO3		2		3		3
CO4				2		2
CO5			2		2	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHODS

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

COURSE INFORMATION SHEET

Course code: BE606
Course title: Process Biotechnology Lab
Pre-requisite(s): BE515 Process Biotechnology
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: III/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Understand the basic mechanism of bacterial growth, regulation of growth and mass balance
2.	Create awareness about various sources of industrial enzyme, production process with case study
3.	Learn the mechanism and significance of sterilization of growth medium and other accessories of fermenter
4.	Understand and identify the process of production of different primary metabolites with some examples
5.	Learn the production of secondary metabolites and their important roles

Course Outcomes

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

CO1.	Calculate kinetic parameters and yield from bacterial growth curve
CO 2.	Determine the effect of parameters on enzyme synthesis
CO 3.	Analyse the role of contaminants and their removal from production process
CO 4.	Evaluate and explore different primary and secondary metabolites

LIST OF EXPERIMENTS:

Experiment-1 Isolation of proteolytic enzymes from soil sample

Experiment-2 Production of citric acid

Experiment-3 Production of baker's yeast

Experiment-4 Preparation of standard plot of protein

Experiment-5 Preparation of standard plot of sugar

Experiment-6 Growth of microorganism and mass balance

Experiment-7 Immobilization of whole cell by entrapment

Experiment-8 Kinetic study of enzyme

Books:

1. Doran, Bioprocess Engineering Principles, Academic Press, 1995
2. Bailey and Ollis, Biochemical Engineering Fundamentals, 1986
3. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

Real time production process of different metabolites

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10
Day to day performance & Lab files	30
Viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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		2	3	1	1
CO2	1		3	3	3	2
CO3	2	1	3	2		3
CO4	2	2	2	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, CD3
CO2	CD1, CD2, CD3,CD4
CO3	CD1, CD2, CD3,CD4, CD6
CO4	CD1, CD3,CD6,CD7

COURSE INFORMATION SHEET

Course code: BE607
Course title: Animal Cell Technology Lab
Pre-requisite(s): BE513 Animal Cell Culture
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: III/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To familiarized with the basic components of animal cell culture lab.
2.	To impart the hands on experience on basic tissue culture techniques.

Course Outcomes

After the completion of this course, students will be:

CO1.	To demonstrate experimental skill of Cell culture techniques and competence in laboratory techniques.
CO2.	To develop proficiency in establishing and maintaining of cell lines.
CO3.	To conduct the independent research in the animal cel culture and its further application.

LIST OF EXPERIMENTS

Experiment-1 Laboratory Design & Instrumentation in ACT.

Experiment-2 Quality Assurance in Animal tissue culture facility.

Experiment-3 Sterilization Techniques in ACTL.

Experiment-4 Preparation of animal cell culture media.

Experiment-5 Isolation and Culturing of Peripheral Blood Lymphocytes.

Experiment-6 Cell counting, Viability assay, Cryopreservation technique.

Experiment-7 Sub-culturing and maintenance of Cell line.

Experiment-8 In vitro anticancer assay (MTT Assay).

Experiment-9 DPPH radical scavenging assay.

Experiment-10 Genomic DNA Isolation from animal tissues.

Text Books

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

Reference books:

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

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

POs met through Gaps in the Syllabus

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics
   POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design

1. Lecture on advanced application of animal cell culture technology
2. Lecture on different case studies and state-of-art techniques.
   POs met through Topics beyond syllabus/Advanced topics/Design are: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10

Day to day performance & Lab files	30
Viva	20

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	2	2	2
CO2	1		2	2	3	3
CO3	1	2	3			2

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

MAPPING BETWEEN CURSE OUTCOMES AND COURSE DELIVERY METHODS

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3
CO2	CD1, CD2, CD3
CO3	CD1, CD32, CD3

COURSE INFORMATION SHEET

Course code: BE608
Course title: Biomedical Instrumentation Lab
Pre-requisite(s): BE518 Biomedical Instrumentation
Co- requisite(s): Nil
Credits: 2 L: 0 T: 0 P: 4
Class schedule per week: 04
Class: M.Tech.
Semester / Level: III/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To impart knowledge for interdisciplinary and applied engineering and technology.
2.	To provide knowledge about different physiological parameters and associated measuring sensors.
3.	To impart practical knowledge about the application of biomedical equipment.
4.	To make them learn about the general processing tools for biomedical signal analysis.

Course Outcomes

After the completion of this course, students will be:

CO1.	Working with the biomedical equipment.
CO2.	Fundamentals of the types of biomedical sensors and transducers for biomedical data acquisition.
CO3.	Fundamentals of biosignals and their pattern analysis.
CO4.	Work in an interdisciplinary team.

LIST OF EXPERIMENTS

Experiment 1: To study and calculate body mass index and its correlation with human health.
Experiment 2: To study different types of electrodes and sensors used in bio-potential recordings.
Experiment 3: To study and measure the non-invasive blood pressure using sphygmomanometer
(a) To evaluate the diastolic pressure.
(b) To evaluate systolic pressure.
(c) To evaluate mean arterial pressure.
Experiment 4: To record and analyse the characteristics of different types of electrolytic medium between electrode and body.
(a) Air-coupled.
(b) Applied water.
(c) Applied electrolytic gel.
(d) Applied disposable electrodes.
Experiment 5: To record and analyse bipolar electrocardiogram for different leads under varied sensory, motor and visual stimulus.
Experiment 6: (a) To record and analyse surface electromyogram in calculating clench strength for both dominating and non-dominating arm with lowest applied clench force.
(b) To record and analyse surface electromyogram in calculating clench strength for both dominating and non-dominating arm with highest applied clench force.
Experiment 7: (a) To record and analyse vertical and horizontal eye ball activity while gazing stationary objects.
(b) To record and analyse vertical and horizontal eye ball activity while tracking moving Objects.
Experiment 8: (a) To record and analyse the phonocardiogram signal.
(b) To correlate the PCG signal with electrical and mechanical cardiac activities.
Experiment 9: (a) To record biopolar and monopolar electroencephalogram (EEG).
(b) To Derive and analyse delta, theta, alpha and beta bands of EEG.
Experiment 10: To study and analyse haemodynamic activity using pulse plethysmography.
Experiment 11: To record and analyse electrodermal activity or galvanic skin response.
Experiment 12: To study and perform lie detector test.

Text Books

1. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown
2. Handbook of Biomedical Instrumentation by R. S. Khandpur
3. Biomedical Instrumentation and Measurement by L. Cromwell et al.

Reference Books

1. Biomedical Digital Signal Processing by W. J. Tompkins
2. Biomedical Signal Processing: Principles and Techniques by D C Reddy.

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

POs met through Gaps in the Syllabus

3. Conducting presentations in group and writing reports
4. Giving assignments to the students on some relevant topics
   POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design

3. Lecture on specialized physiological sensing
4. Lecture on human-machine interaction
   POs met through Topics beyond syllabus/Advanced topics/Design are: **PO3**

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Continuous Internal Assessment	% Distribution
Quizzes	10
Day to day performance & Lab files	30
Viva	20

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

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	2	2	2
CO2	1		2	2	2	3
CO3	1	2	3			2
CO4					3	3

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

Mapping Between Curse Outcomes and Course Delivery Methods

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

COURSE INFORMATION SHEET

Course code: BE650
Course title: Thesis Part II
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 16 L: T: P:
Class schedule per week:
Class: M.Tech.
Semester / Level: IV/06
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Solve real world problems and challenges
2.	Solve the various research challenges in the field of Biochnology
3.	Create awareness among the students of the characteristics of several domain areas where their project ideas could help humanity
4.	Improve the team building, communication and management skills of the students

Course Outcomes

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

CO1.	Demonstrate a sound technical knowledge of their selected project topic
CO 2.	Undertake problem identification, formulation and solution
CO 3.	Design biotechnological solutions to complex problems utilizing a systems approach
CO 4.	Communicate with scientists/engineers and the community at large in written and oral forms
CO5	Demonstrate the knowledge, skills and attitudes of a professional biotechnologist.

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment	60
Semester End Examination	40

Assessment Components	CO1	CO2	CO3	CO4	CO5
Continuous Internal Assessment					
Semester End Examination					

Indirect Assessment –

1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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