BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEWCOURSE STRUCTURE - To be effective from academic session 2018- 19
Based on CBCS & OBE model
Recommended scheme of study
B. Tech (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**
GRAND TOTAL FOR FIRST YEAR								**43.5**
THIRD Monsoon				**THEORY**				
	SECOND	**FS**	MA203	Numerical Methods	2	0	0	2
	FIRST		CE101	Environmental Sciences	2	0	0	2
	SECOND	**PC**	BE202	Cell and Molecular Biology	3	0	0	3
			BE203	Microbiology	3	0	0	3
			BE204	Biochemistry and Enzyme Technology	3	0	0	3
			BE205	Basics of Bioinformatics	3	1	0	4
			BE206	Chemical Process Calculations	3	0	0	3
				LABORATORIES				
	SECOND	**GE**	IT202	Basic IT Workshop	0	0	2	1
		FS	MA204	Numerical Methods Lab	0	0	2	1
		MC	MC201/202/ 203/204	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
		PC	BE207	Cell Biology and Biochemistry Lab.	0	0	3	1.5
TOTAL								**24.5**
FOURTH Spring				**THEORY**				
	SECOND	**GE**	IT201	Basics of Intelligent Computing	3	0	0	3
	FIRST	**FS**	BE101	Biological Science for Engineers	2	0	0	2
	SECOND	**PC**	BE208	Biology of Immune System	3	0	0	3
			BE209	Fluid Mechanics & Heat Transfer	3	0	0	3
			BE210	Thermodynamics of Chemical & Biological Systems	3	0	0	3
		PE		Programme Elective -I	3	0	0	3
		OE		Open Elective – I	3	0	0	3
				LABORATORIES				
	FIRST	**GE**	EE102	Electrical Engineering Lab	0	0	3	1.5
	SECOND	**MC**	MC205/206/ 207/208	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
		PC	BE211	Microbiology and Immunology Lab.	0	0	3	1.5
			BE212	Fluid Mechanics & Heat Transfer Lab	0	0	3	1.5
TOTAL								**25.5**

FIFTH Monsoon	**THEORY**							
	FIRST	**HSS**	MT123	Business Communications	2	0	2	3
	THIRD	**PC**	BE301	Bio-analytical techniques	3	0	0	3
			BE302	Functional Genomics and rDNA Technology	3	0	0	3
			BE303	Mass Transfer Operations	3	0	0	3
			BE304	Reaction Engineering	3	0	0	3
		PE		Programme Elective -II	3	0	0	3
		OE		Open Elective - II	3	0	0	3
	LABORATORIES							
	THIRD	**PC**	BE305	Molcular Biology & rDNA Technology Lab	0	0	3	1.5
			BE306	Bio-analytical Lab.	0	0	3	1.5
TOTAL								**24**
SIXTH Spring	**THEORY**							
	THIRD	**PC**	BE307	Bioprocess Engineering	3	0	0	3
			BE308	Bioseparation Engineering	3	0	0	3
			BE309	Fermentation Engineering	3	0	0	3
		PE		Programme Elective -III	3	0	0	3
		OE		Open Elective - III/MOOC I	3	0	0	3
		MC	MC300	Summer Training	N/A			3
	LABORATORIES							
	THIRD	**PC**	BE310	Bioprocess Engineering Lab.	0	0	3	1.5
			BE311	Mass Transfer and Bioseparation Engg. Lab	0	0	3	1.5
TOTAL								**21**
SEVENTH Monsoon	**THEORY**							
	FOURTH	**HSS**	BE401	Professional Practice, Law and Ethics	2	0	0	2
		PC	BE402	Bioreactor and Bioprocess design	3	1	0	4
		PC	BE403	Plant & Agriculture Biotechnology	3	0	0	3
		PE		Programme Elective -IV	3	0	0	3
		OE		Open Elective- IV/ MOOC II	3	0	0	3
	SECOND	**MC**	MT204	Constitution of India	2	0	0	NC
	LABORATORIES							
	FOURTH	**PC**	BE404	Plant Cell Technology Lab.	0	0	3	1.5
TOTAL								**16.5**
EIGTH Spring	**FOURTH**	**PC**	BE400	Research Project / Industry Internship	**Total**			**12**
GRAND TOTAL ***Minimum requirement for Degree award***								**167**

DEPARTMENT OF BIOENGG.
PROGRAMME ELECTIVES (PE)*B.Tech Biotechnology
OFFERED FOR LEVEL 1-4

PE / LEVEL		Code no.	Name of the PE courses	Prerequisites/Corequisites courses with code	L	T	P	C
2	PE 1	BE213	Pharmaceutical Biotechnology	BE202, BE204	3	0	0	3
		BE214	Natural Product Biotechnology	BE202, BE204	3	0	0	3
		BE215	Cellular Electrophysiology	EC101, BE202	3	0	0	3
		BE216	Enzyme Technology	BE202, BE204	3	0	0	3
3	PE 2	BE312	Biomaterials	BE204	3	0	0	3
		BE313	Metabolic Engineering	BE202, BE204	3	0	0	3
		BE314	Biosignal acquisition and analysis	EC101, BE215	3	0	0	3
		BE315	Food Science and Technology	BE204	3	0	0	3
		BE316	Bioinformatics Algorithms	BE205	3	0	0	3
3	PE 3	BE317	Stem cell and Tissue Engineering	BE202, BE204, BE302	3	0	0	3
		BE318	Bioenergy and Biofuels	BE202, BE209, BE303	3	0	0	3
		BE319	Bioelectronics–Concept & Instrumentation	BE314	3	0	0	3
		BE320	Biotreatment of Municipal and Industrial wastes	CE101, BE303	3	0	0	3
		BE321	Cheminformatics	BE204, BE205, BE304	3	0	0	3
4	PE 4	BE407	Nanobiotechnology		3	0	0	3
		BE408	Mineral Biotechnology		3	0	0	3
		BE409	Rehabilitation Engineering		3	0	0	3
		BE410	Process Measurement and Control	EC101, BE307	3	0	0	3
		BE411	Molecular Modelling and Drug Design	BE205	3	0	0	3
		BE412	Process Biotechnology	BE307	3	0	0	3

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

DEPARTMENT OF BIO-ENGG.
OPEN ELECTIVES (OE)*
OFFERED FOR LEVEL 1-4

OE / LEVEL	Code no.	Name of the PE courses	Prerequisites/Corequisites courses with code	L	T	P	C
OE/2	BE203	Microbiology	NIL	3	0	0	3
OE/2	BE204	Biochemistry and Enzyme Technology	NIL	3	0	0	3
OE/2	BE205	Basics of Bioinformatics	NIL	3	0	0	3
OE/2	BE213	Pharmaceutical Biotechnology	NIL	3	0	0	3
OE/3	BE316	Bioinformatics Algorithms	NIL	3	0	0	3
OE/3	BE319	Bioelectronics–Concept & Instrumentation	NIL	3	0	0	3
OE/3	BE320	Biotreatment of Municipal and Industrial wastes	NIL	3	0	0	3
OE/4	BE407	Nanobiotechnology	NIL	3	0	0	3
OE/4	BE411	Molecular Modelling and Drug Design	NIL	3	0	0	3

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

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

Biotechnology Minor to B.Tech (Other than Biotechnology)

Semester/ Session of Study (Recomended)	Course Level	Category of Course	Course Code	Courses	Prerequisite/ Corequisite	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									
Fifth Monsoon	Second	PC	BE202	Cell & Molecular Biology		3	0	0	3
	Third	PC	BE322	Biochemistry & Microbiology		3	1	0	4
TOTAL									7
Sixth Spring	Second	PC	BE213	Pharmaceutical Biotechnology	BE202	3	1	0	4
	Third	PC	BE307	Bioprocess Engineering	BE322	3	0	0	3
TOTAL									7
Seventh Monsoon	Fourth	PC	BE412	Process Biotechnology	BE307	3	0	0	3
	Fourth	PC	BE415	Basic Biotechnology Lab	BE322	0	0	3	1.5
	Fourth	PC	BE416	Process Biotechnology Lab	BE322	0	0	3	1.5
TOTAL									6
GRAND TOTAL CREDITS (Minimum requirement for minor degree award)									**20**

BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI
NEWCOURSE STRUCTURE - To be effective from academic session 2018- 19
Based on CBCS & OBE model, Recommended scheme of study for
In-depth Specialization in Computational Biotechnology with B. Tech (Biotechnology)

Level (Recomended)	Course Code	Course	Prerequisite/ Corequisite	Mode of delivery & credits *L-Lecture; T-Tutorial; P-Practicals*			Total Credits *C- Credits*
				L (*Periods/ week*)	**T *(Periods/ week)***	**P *(Periods/ week)***	**C**
THIRD	**THEORY**						
	BE316	Bioinformatics Algorithms		3	0	0	3
	BE328	Molecular Simulation of Biomolecules		3	1	0	4
	BE329	Perl & Bioperl Programming		3	1	0	4
	BE321	Cheminformatics	BE205	3	0	0	3
	BE330	Biosequence analysis and Programming lab	BE328, BE329	0	0	3	1.5
FOURTH	BE415	System Biology	BE204, BE205	3	0	0	3
	BE417	Molecular modelling & Drug Design Lab	BE321, BE328	0	0	3	1.5
TOTAL CREDITS							**20**

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

Biomedical Medical Instumentation Minor to B.Tech (Other than Biotechnology)

Semester/ Session of Study (Recomended)	Course Level	Category of Course	Course Code	Courses	Prerequisite/ Corequisite	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									
Fifth Monsoon	Third	PC	BE322	Biosignal Acquisition and Analysis	NIL	3	0	0	3
		PC	BE323	Applied Anatomy and Physiology	NIL	3	0	0	3
	Third	PC	BE324	Electrophysiology Lab	NIL	0	0	3	1.5
TOTAL									7.5
Sixth Spring	Third		BE325	Medical Electronics and Device	BE322	3	0	0	3
	Third	PC	BE326	Imaging techniques in healthcare	BE322	3	0	0	3
	Third	PC	BE327	Signal Processing Lab	BE324	0	0	3	1.5
TOTAL									7.5
Seventh Monsoon	Fourth	PC	BE413	Biomechanical systems and Rehabilitation Engineering	BE325	3	0	0	3
	Fourth	PC	BE414	Health Informatics and Telemedicine	NIL	3	0	0	3
TOTAL									6
GRAND TOTAL CREDITS (Minimum requirement for minor degree award)									**21**

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.

Vision of Department

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

Mission of Department

- 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 bio entrepreneurship.

Sl. No.	**Programme educational objectives**
PEO 1	To produce graduates in Biotechnology with strong technical competence in Bio-science, -technology, -engineering and management.
PEO 2	To develop teamwork and awareness amongst students towards the importance of multidisciplinary approach for problem solving skills in Biotechnology.
PEO 3	To develop trained human resource in Biotechnology to promote quality education and to initiate life-long learning process for productive career.
PEO 4	To generate potential knowledge pools with interpersonal and collaborative skills to identify, assess and formulate problems and execute the solution in closely related biological industries.

Program Educational Objectives (PEO)

- Students will acquire necessary knowledge and skills in the frontier areas of Biotechnology.
- Students will think critically and creatively about the use of biotechnology to address local and global problems.
- 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.

Programme Outcomes

The student will have

a. An ability to apply knowledge of mathematics, science, and engineering
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system, component, or process to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. An ability to identify, formulate, and solve engineering problems
e. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.
f. The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
g. Graduates are trained to maintain the green catalysts philosophy with sustainability of various environmental resources.
h. An understanding of professional and ethical responsibility
i. An ability to function in multidisciplinary teams
j. An ability to communicate effectively
k. An ability to demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work
l. A recognition of the need for and an ability to engage in life-long learning

COURSE INFORMATION SHEET

Course code: CE101
Course title: ENVIRONMENTAL SCIENCE
Pre-requisite(s): NA
Co- requisite(s): NA
Credits:2 L:2 T:0 P:0
Class schedule per week: 02
Class: B. Tech.
Semester / Level: 03/01
Branch: All
Name of Teacher:

Course Objectives

This course enables the students:

1.	To develop basic knowledge of ecological principles and their applications in environment.
2.	To identify the structure and composition of the spheres of the earth, the only planet sustaining life.
3.	To analyse, how the environment is getting contaminated and probable control mechanisms for them.
4.	To generate awareness and become a sensitive citizen towards the changing environment.

Course Outcomes

After the completion of this course, students will be:

	Able to explain the structure and function of ecosystems and their importance in the holistic environment.
	Able to identify the sources, causes, impacts and control of air pollution.
	Able to distinguish the various types of water pollution happening in the environment and understand about their effects and potential control mechanisms.
	Able to judge the importance of soil, causes of contamination and need of solid waste management.
	Able to predict the sources of radiation hazards and pros and cons of noise pollution.

Syllabus

Module 1. Ecosystem and Environment [8]

Concepts of Ecology and Environmental science, ecosystem: structure, function and services, Biogeochemical cycles, energy and nutrient flow, ecosystem management, fate of environmental pollutants, environmental status and reports on climate change.

Module 2: Air Pollution [8]

Structure and composition of unpolluted atmosphere, classification of air pollution sources, types of air pollutants, effects of air pollution, monitoring of air pollution, control methods and equipment for air pollution control, vehicular emissions and control, indoor air pollution, air pollution episodes and case studies.

Module 3: Water Pollution [8]

Water Resource; Water Pollution: types and Sources of Pollutants; effects of water pollution; Water quality monitoring, various water quality indices, water and waste water treatment: primary, secondary and tertiary treatment, advanced treatments (nitrate and phosphate removal); Sludge treatment and disposal.

Module 4: Soil Pollution and Solid Waste Management [8]

Lithosphere – composition, soil properties, soil pollution, ecological & health effects, Municipal solid waste management – classification of solid wastes, MSW characteristics, collection, storage, transport and disposal methods, sanitary landfills, technologies for processing of MSW: incineration, composing, pyrolysis.

Module 5: Noise pollution & Radioactive pollution [8]

Noise pollution: introduction, sources: Point, line and area sources; outdoor and indoor noise propagation, Effects of noise on health, criteria noise standards and limit values, Noise measurement techniques and analysis, prevention of noise pollution; Radioactive pollution: introduction, sources, classification, health and safety aspects, Hazards associated with nuclear reactors and disposal of spent fuel rods-safe guards from exposure to radiations, international regulation, Management of radioactive wastes.

Text books:

1. A, K. De. (3rd Ed). 2008. Environmental Chemistry. New Age Publications India Ltd.
2. R. Rajagopalan. 2016. Environmental Studies: From Crisis to Future by, 3rd edition, Oxford University Press.
3. Eugene P. Odum. 1971. Fundamentals of Ecology (3rd ed.) -. WB Sunders Company, Philadelphia.
4. C. N. Sawyer, P. L. McCarty and G. F. Parkin. 2002. Chemistry for Environmental Engineering and Science. John Henry Press.
5. S.C. Santra. 2011. Environmental Science. New Central Book Agency.

Reference books:

1. D.W. Conell. Basic Concepts of Environmental Chemistry, CRC Press.
2. Peavy, H.S, Rowe, D.R, Tchobanoglous, G. Environmental Engineering, Mc-Graw - Hill International
3. G.M. Masters & Wendell Ela. 1991. Introduction to Environmental Engineering and Science, PHI Publishers.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓
Seminars	✓
Mini projects/Projects	✓
Laboratory experiments/teaching aids	✓
Industrial/guest lectures	✓
Industrial visits/in-plant training	✓
Self- learning such as use of NPTEL materials and internets	✓
Simulation	✓

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Quiz (s) (1 & 2)	10+10
Teacher's assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid sem exam	✓	✓	✓		
End Sem Examination Marks	✓	✓	✓	✓	✓
Quiz 1	✓	✓			
Quiz 2			✓	✓	✓
Assignment	✓	✓	✓	✓	✓

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Graduate Attributes

Course Outcome #	Program outcomes												Program specific outcomes		
1.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1**	**1**	**1**	**1**	**2**	**3**
2.		**1**	**3**			**1**	**3**			**0**	**1**	**2**	**1**		
3.		**1**	**3**			**1**	**3**						**1**		
4.		**1**	**3**			**1**	**3**						**1**		
5.		**1**	**3**			**1**	**3**						**1**		

Mapping Between COs and Course Delivery (CD) methods

CD	Course Delivery methods		Course Outcome	Course Delivery Method
CD 1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD8
CD 2	Tutorials/Assignments		CO2	CD1, CD2, CD8
CD 3	Seminars		CO3	CD1, CD2, CD8
CD 4	Mini projects/Projects		CO4	CD1, CD2, CD8
CD 5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD8
CD 6	Industrial/guest lectures			
CD 7	Industrial visits/in-plant training			
CD 8	Self- learning such as use of NPTEL materials and internets			
CD 9	Simulation			

COURSE INFORMATION SHEET

Course code: BE101
Course title: Biology for Engineers
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: 2 L:2 T:0 P:0
Class schedule per week: 02
Class: B. Tech
Semester / Level: III-IV /I
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

1.	Recognize and understand the basic cell biology, biomolecules, related metabolic pathways and applicable bioenergetics.
2.	Relate common biological phenomenon at molecular level.
3.	Describe the chemical nature of enzymes and mechanism of action for their function in biochemical reactions.
4.	Correlate the molecular methods of biological signal generation and propagation in living system.
5.	Comprehend the steps involved in common application of biotechnology such as applicable for creation of transgenics, stem cells, plant metabolites production PCR, ELISA.

Course Outcomes

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

CO1	Demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules involved in living system.
CO2	Interpret the biomechanism involved in signal generation and transmission.
CO3	Correlate the basic methods involved in common biotechnological application.
CO4	Apply and effectively communicate scientific reasoning and data involved in common biotechnological applications.

BE101 Biological Science for Engineers

Credit:2

Module-1: Basic Cell Biology: [6L]

Origin of life, Cell theory, Cell Structure and function, Biomolecules, Cell cycle and cell division, Biological Organization.

Module-2: Bioenergetics and Metabolism: **[6L]**

Gibbs free energy and thermodynamics, aerobic and anaerobic respiration, Glycolysis, Krebs cycle and electron transport chain, Beta oxidation, Photosynthesis.

Module-3: Enzymes and its Application: [6L]

Classification of enzymes, Structure and mechanism of enzyme action and uses of enzymes, factors affecting enzyme activity, Immobilization of enzymes and their application.

Module-4: Biological Signal Generation and Propagation: [6L]

Nerve cell structure and signal propagation. Mechanism of vision and hearing, cell signaling, Circadian rhythm.

Module-5: Engineering Biological Systems and its Applications: [6L]

Central dogma of molecular biology, Methods in genetic engineering and application, PCR, ELISA and its application, stem cell and tissue engineering. Artificial Intelligence in Biology, Plant factory.

Books Recommended

Recommended Text Book

1. Purves et al, (1998) Life: *The Science of Biology,* 4th Ed.
2. R. Dulbecco, The Design of Life.
3. Lehninger A, Principals of Biochemistry, 5th Ed

Reference Book

1. Stryer, L. (2002). *Biochemistry*. New York: W.H. Freeman.
2. K. Wilson & K.H. Goulding, (2006) *A biologist's guide to Principles and Techniques of Practical Biochemistry*.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure
Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	√	√	√	√
End Sem Examination Marks	√	√	√	√
Quiz I	√	√	√	
Quiz II	√	√	√	

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	3	1	1	1	2	1	1	1	1
2	3	3	3	3	1	1	1	2	1	1	1	1
3	1	3	3	3		1	1	1		1	1	1
4	2	2	2	2		2	2	2		1	1	2

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3, 4	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO1, 2, 3, 4	CD1, CD2, CD3, CD8
CD3	Seminars		
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: BE 202
Course title: Cell and Molecular Biology
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: III rd
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Build on the knowledge of cell structure and function gained and understand how eukaryotic cells work at the molecular level.
2.	Provide an overview of cell structure and function at the molecular level, including the flow of information from genes to proteins, and regulation of cellular processes, signaling and proliferation in eukaryotic cells.
3.	Introduce some of the major ideas and experimental approaches in cell and molecular biology
4.	Develop basic knowledge and skills in cell and molecular biology
5.	Become aware of the complexity and harmony of the cell.

Course Outcomes

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

CO1	Integrate the different levels of biological organization, from molecules to cells to organisms.
CO2	Gather, critically assess, and utilize primary scientific literature to research a topic.
CO3	Demonstrate the knowledge of common and advanced laboratory practices in cell and molecular biology
CO4	Exhibit clear and concise communication of scientific data
CO5	Understand and practice the ethics surrounding scientific research
CO6	Plan for professional growth and personal development within and beyond the undergraduate program.

(BE202) CELL & MOLECULAR BIOLOGY

Credit: 3

Module-1: Cell Basics: [8L]
Structure of prokaryotic and eukaryotic cell, Electron micrograph of cell wall, cell membranes, Freeze Fracture technique, Patch clamp method, FRAP, cell organelles.

Module-2: Cell-cell Interaction and Signaling: [8L]

Principles of cell communication, Principles of cell signaling, Signaling via G-Protein linked cell-surface Receptors and Signaling via enzyme- linked cell-surface receptors, Target cell adaptation, Signal transduction pathways.

Module-3: Cell Cycle and its Regulation: [8L]
Components of the cell cycle, Regulation of cell cycle progression, Intracellular control of the cell cycle events, Extracellular control of cell division, Cell growth, and apoptosis, Regulation of meiotic cell cycle.

Module-4: Basic Genetic Mechanism: [8L]
DNA replication, DNA repair, DNA methylation, RNA splicing, RNA editing. Protein synthesis, Chromatin packing, Genetic recombination, Manipulating Proteins, Membrane transport mechanism, Control of gene expression.

Module-5: Protein Processing & Transportation: [8L]
Intracellular Compartmentalization, Protein targeting, mechanism of co-translational transport of protein, Post-translational transport of protein into organelles, Protein entry sorting and modification, Protein degradation.

Books Recommended
Text Books
T1. Channarayappa: Molecular Biology
T2. U. Satyanarayana: Biotechnology
Reference Books:
R1. Alberts et al, Molecular Biology of the Cell
R2. Lodish et al, Molecular Cell Biology
R3. DeRobertis, Cell Biology
R4. Harper, The Cell

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors√
Tutorials/Assignments√
Seminars√
Mini projects/Projects
Laboratory experiments/teaching aids√
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets√
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	√	√				
End Sem Examination Marks	√	√	√	√	√	√
Quiz I	√	√	√			
Quiz II				√		√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3		1									
2	3	2	2									
3	3		2		2							
4	3					2			2	3		
5		1	1			1		2				
6				3			3					2

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: BE203
Course title: Microbiology
Pre-requisite(s): Basics of Biological Sciences
Co- requisite(s): Microbiology Lab
Credits: L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: III
Branch: Bio-Engineering
Name of Teacher:

Course Objectives

This course enables the students:

1.	To establish an understanding of the major historical events and basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	To describe basic cell structure, metabolism, nutrition, reproduction and ecology of prokaryotic microorganisms, eukaryotic microorganisms and viruses
3.	To describe microbial interactions and their significance in agriculture, food and pharmaceuticals
4.	To outline principles of physical and chemical methods used in the control of microorganisms and apply this understanding to the prevention and control of infectious diseases
5.	To describe nonspecific body defenses and the immune responses and apply this understanding to the infectious disease process as well as the prevention and control of infectious diseases
6.	To develop and execute oral and writing skills necessary for effective communication of the course, the ability to think critically regarding a topic and the delivery of scientific principles to both scientists and non-scientists

Course Outcomes

After the completion of this course, students will be:

CO1	Identify microbiological techniques, microbial evolution, phylogeny and know the defining characteristics of the major groups of microorganisms
CO2	Describe the structure, function and growth of bacteria, structure of viruses
CO3	Evaluate the industrially important microbes and also how microorganisms interact with the environment in beneficial or detrimental ways
CO4	Assess plant- microbe interaction in beneficial or detrimental ways
CO5	Determine ways in which microorganisms play an integral role in disease, and the microbial and immunological methodologies are used in disease treatment and prevention
CO6	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and communicate with both specialist and non-specialist audiences using genres commonly used in microbiology

(BE203) MICROBIOLOGY

Module-I Basics of Microbiology: [8L]

Brief history on the development and scope of microbiology, Methods in Microbiology-Microscopy, Methods of sterilization; culture media, Pure culture methods, Staining of Bacteria, Micrometry, Air sampling, Classification of microorganisms

Module-II Growth of Microorganism: [8L]

Cell structure and major characteristics of cellular (bacteria, fungi, algae, protozoa) and acellular (viruses) organisms, Archaebacteria, Growth of Microorganisms: Nutritional and physical requirements, Batch culture, Continuous culture, Synchronous growth, Fed-batch culture

Module-III: Environmental & Industrial Microbiology: **[8L]**

Water treatment, Bacteriological analysis of water, Bioleaching, Bioremediation, Industrially important micro-organisms and secondary metabolites.

Module-IV: Agricultural Microbiology: **[8L]**

Plant-microbial interactions, Biodeterioration of agricultural products, control of microbes and safe storage of agricultural products/food.

Module-V: Medical Microbiology: **[8L]**

Microbial flora of healthy human host, host-pathogen interactions in animals, Diseases caused by bacteria, virus, fungi and protozoans; natural resistance and nonspecific defense mechanisms.

Text books:

T1. Prescott, Harley, and Klein, Microbiology, 7th Ed., Tata McGraw-Hill, 2008

Reference books:

R1. Pelczar, Chan and Krieg, Microbiology, 5th Edition, Tata McGraw-Hill, 1986

R2. Frazier and Westhoff, Food Microbiology, 4th Edition, Tata McGraw-Hill, 1995

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors✓
Tutorials/Assignments✓
Seminars✓
Mini projects/Projects
Laboratory experiments/teaching aids✓
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets✓
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	√	√				√
End Sem Examination Marks	√	√	√	√	√	√
Assignment*		√	√	√	√	√
Quiz I	√	√	√			
Quiz II				√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3					2						
2	3		3		2	2						
3	3		3			2						
4	3		3		3	2						
5			3		3	2						
6		2			3				2	2		1

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD5 and CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3 and CD8
CD3	Seminars	CO3	CD1, CD2, CD3 and CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD3 and CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD3 and CD8
CD6	Industrial/guest lectures	CO6	CD2, CD4, CD5
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: BE 204
Course title: Biochemistry & Enzyme Technology
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: IIIrd
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to :

1.	Describe/recognize structure & function of biomolecules, Compare & contrast DNA and RNA, mono-, di-, and polysaccharides and lipid structures, including lipids found in cell membranes and their transport across membranes, describe their physical and chemical properties and their function in living organisms, Define primary, secondary, tertiary and quaternary structure in proteins and identify the types of interactions important in each case. Recognize biological membrane's structure, gated channels and transport processes. understand biosynthesis of lipids and their regulations, summarize the function of protein
2.	Describe what happens during carbohydrate digestion, glycolysis, glycogenesis, and glycogenolysis, Citric acid cycle & the electron transport chain and oxidative phosphorylation and fatty acid oxidation. Understand biosynthesis of lipids and their regulations. Explain and give examples of the strategies of metabolism, emphasizing the role of ATP coupled reactions, and coenzymes that exist in oxidized and reduced form
3.	List the essential and non-essential amino acids and describe the general strategies for amino acid synthesis. Describe biosynthesis of various amino acids and understand their regulation. Explain what happens during digestion of proteins, catabolism of amino acids and the urea cycle. Understand biological processes like biosynthesis of nucleic acids and their catabolism.
4.	Describe the chemical nature of enzymes and their function in biochemical reactions. Explain how enzyme activity is (a) regulated, and (b) affected by temperature, pH, and concentration. Describe Allosteric enzymes. Explain mode of enzyme action, Describe and compare enzyme inhibition.
5.	Impart knowledge about the enzyme immobilization, methods of enzyme immobilization and their applications in textile, food and pharmaceutical industry. Gain concept regarding enzyme stability and methods involved.

Course Outcomes

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

CO1	Demonstrate an understanding of fundamental biochemical principles, such as the structure/function of biomolecules.
CO2	Understanding of metabolic pathways and the regulation of biological/biochemical processes.
CO3	Be capable of undertaking suitable experiments/research methods.
CO4	Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums.
CO5	Understand and practice the ethics surrounding scientific research.
CO6	Understanding of societal and environmental issues and deriving a solution to a problem

(BE204) BIOCHEMISTRY& ENZYME TECHNOLOGY

Credit:3

Module-1: Biomolecules: [8L]

structure & function- Structure of nucleic acids, DNA double helix, Chargaff's rule, Types of DNA and RNA, Organization of eukaryotic DNA, Classification, Structure and function of carbohydrates (mono, oligo & polysaccharides),standard amino acids, physicochemical properties of amino acids, Structure of proteins, levels of organization, Ramachandran plot, Characteristics of protein denaturation, Classification and functions of lipids (simple, compound & derived lipid with examples), Essential fatty acids, Biological membrane structure, Gated channels and transport processes.

Module-2: Carbohydrate & Lipid Metabolism: [8L]

Glycolysis, Gluconeogenesis, Kreb's Cycle, Electron transport chain, Oxidative phosphorylation, Biosynthesis of carbohydrates and their regulations, Beta and omega oxidation pathway, malate-aspartate and citrate shuttle, Biosynthesis of fatty acids.

Module-3: Amino acid & Nucleic acid metabolism: [8L]

Biosynthesis of tryptophan and glutamic acid, general pathways of amino acid metabolism, Deamination, Transamination, decarboxylation reactions, detoxification of ammonia, synthesis of purines & pyrimidines and degradation of nucleic acids.

Module-4: Enzymes: [8L]

Enzyme classification, Concept of apoenzyme and holoenzyme, Mechanism of enzyme action, Mechanism of enzyme catalysis, Enzyme kinetics, Specific activity, Factors affecting enzyme activity. Types &Mechanism of enzyme inhibition, Enzyme turnover number, Feedback regulation, allosteric enzymes.

Module-5: Immobilization of Enzymes and Enzyme Stabilization: [8L]

Methods of enzyme immobilization, production and application of free and immobilized enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics. Kinetics of immobilized enzymes. Stability of enzymes: Enzyme stabilization by selection and genetic engineering, protein engineering, reaction environment rebuilding.

Text Books:

T1. Eric E. Conn& P.K. Stumpf, Outlines of Biochemistry
T2. U. Satyanarayana and U. Chakrapani: Biochemistry
T3. R.K. Murray, D.K. Granner Et Al., Harper's Biochemistry

Reference Books:

R1. D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, 3rd Edition (2002) McMillan North Publication.
R2. Lubert Stryer, Jeremy M. Berg, John L. Tymoczko: Biochemistry
R3. Voet &Voet, Biochemistry

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	√	√				√
End Sem Examination Marks	√	√	√	√	√	√
Assignment*		√	√	√	√	√
Quiz I	√	√	√			
Quiz II				√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3		2									
2	3	3	2	2	3							
3	3	3	2		3	2			2			
4	2		3			2			2	2		
5		1	3			2		2				
6			3	3			3			2		1

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: BE205
Course title: Basics of Bioinformatics
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: 4 L:3 T:1 P:0
Class schedule per week: 4
Class: B. Tech
Semester / Level: III
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	Basic objective is to give students an introduction to the basic principle of bioinformatics
2.	Able to explain the major steps in pairwise and multiple sequence alignment, explain the principle for, and execute pairwise sequence alignment by dynamic programming
3.	Evolutionary tree generation and find the ancestor.
4.	Able to predict the secondary and tertiary structures of protein sequences.
5.	Provide practical training in bioinformatics methods including accessing the major public sequence databases

Course Outcomes

After the completion of this course, students will be:

CO1.	Become familiar with the use of a wide variety of internet applications, biological database and will be able to apply these methods to research problems
CO2.	Analyze and discuss the results in light of molecular biological knowledge
CO3.	Development of useful tools for automation of complex computer jobs, and making these tools accessible on the network

(BE205) Basics of Bioinformatics

Module 1: Introduction: [9]

What is bioinformatics and its relation with molecular biology, Different File formats: sequence and structure, General Introduction of Biological Databases; Nucleic acid databases (NCBI, DDBJ, and EMBL); Protein databases (Primary, Composite, and Secondary); Specialized Genome databases: (SGD, TIGR, and ACeDB); Structure databases (CATH, SCOP)

Module 2: Homology and Programming: [9]

Similarity, Identity, Homology, Selectivity/Sensitivity, Linear and Affine Gap Penalty, Basics of Scoring system and matrices (PAM, BLOSUM). Dot matrix method, Global (Needleman-Wunsch) and Local Alignment (Smith-Waterman) using Dynamic programming. BLAST and FASTA, Theory and Algorithms. Multiple Sequence Alignment: Basic Concepts.

Module 3: Molecular Phylogenetics: [9]

Molecular Phylogenetics: Basics, molecular clock, Substitution Models of evolution, Tree reconstruction methods (Distance based, character-based method, statistical).

Module 4: Protein Structure: [9]
Protein Structure: Primary, Secondary, Super Secondary, Domains, Tertiary, Quaternary, Ramachandran plot. Protein secondary structure prediction methods: J-Pred. Protein Tertiary structure prediction methods: Homology Modelling (Modeller and Swiss Model)

Module 5: Current Advancements in Bioinformatics: [9]
Current Advancements in Bioinformatics: Introduction to System Biology, Structural Biology, Structural bioinformatics, Chemoinformatics, Immunoinformatics.

Text books:

T1. Introduction to Bioinformatics by Aurther M lesk
T2. Developing Bioinformatics Computer Skills By: Cynthia Gibas, Per Jambeck

Reference books:

R1. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Benjamin- Cummings Pub Co (Sept 2002, ISBN 0805346333)
R2. David W. Mount (2001) Bioinformatics: Sequence and Genome Analysis. Cold Spring harbor Press

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3
Mid Sem Examination Marks	√	√	
End Sem Examination Marks	√	√	√
Quiz I	√	√	
Quiz II		√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
CO1	3	3		3			3					
CO2	3		3		3							
CO3								2			2	1

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1
CD2	Tutorials/Assignments	CO2	CD1
CD3	Seminars	CO3	CD1 and CD2
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: BE 206
Course title: Chemical Process Calculations
Pre-requisite(s): NIL
Co- requisite(s): NIL
Credits: L: 3 T: 0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: Third
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

1.	To acquire a concept of degree of freedom and its application to solution of mass and energy balance equations for single and network of units
2.	The course will cover concepts ranging from basics such as units and dimensions, stoichiometry to the simultaneous application of material and energy balances with and without occurrence of chemical reaction.
3.	Further humidity along with the use of humidity chart will be covered in the course.

Course Outcomes

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

CO1	Understand the fundamentals of units and stoichiometric equations.
CO2	Write material balance for different chemical process.
CO3	Write energy balance for different chemical process.
CO4	Do humidity calculations.

(BE206) CHEMICAL PROCESS CALCULATIONS

3 Credits

Module-I: Chemical engineering calculations- [8]

Units and dimensions, mole units, basis of calculations, the chemical equation and stoichiometry, dimensional analysis.

Module-II: Material balance fundamentals: [8]

conversion and yield, material balance problems that do not involve chemical reactions.

Module-III: Material balance problems: [8]

Material that involve chemical reactions, recycle, bypass and purge calculations.

Module-IV: Energy balance concepts: [8]

Energy balance concepts and units, enthalpy changes, general energy balance that do not involve reactions.

Module-V: Energy balance that involves chemical reactions: [8]

Energy balance that involves chemical reactions, Heat of solution and mixing, Humidity charts and their use.

Text books:

T1. Himmelblau, D.M., "Basic Principles and Calculations in Chemical Engineering", EEE Sixth Edition, Prentice Hall Inc., 2003

T2. Felder, R. M. and Rousseau, R. W., "Elementary Principles of ChemicalProcesses",3rd Edn., John Wiley & Sons, New York, 2000.

T3. Bhatt, B.L., Vora, S.M., "Stoichiometry ", 4th Edition, Tata McGraw-Hill (2004)

Reference books:

R1. Hougen O A, Watson K M and Ragatz R A, "Chemical process principles" Part I CBS publishers (1973).

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	√	√		
End Sem Examination Marks	√	√	√	√
Quiz I	√	√		
Quiz II			√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	2	2	1	2							
2			3	3	3				2	1		
3		3	3						2	1		
4			3	3	3	3					3	

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1, 2, 3,4	CD1
CD2	Tutorials/Assignments	CO2	CD1, CD8
CD3	Seminars	CO3,4	CD1 and CD2
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: IT201
Course title: **Basics of Intelligent Computing**
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: II/2
Branch: All

Course Objectives
This course enables the students:

A.	To know the basic functions of different AI branches.
B.	To understand the functionalities of IoT .
C.	To know the application of fuzzy logic.
D.	To understand the basic functionalities of a cloud based system.
E.	To find the basic functions of soft computing.

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

1.	Identify the difference between different branches of AI.
2.	Analyze a fuzzy based system.
3.	Design Neural Networks to solve problems.
4.	Analyze a problem in terms of ANN point of view.
5.	Identify the components of a cloud-based system.

IT201 Basics of Intelligent Computing

Module I
Introduction
Definition of Computing, Conventional Computing vs. Intelligent Computing, Necessity of Intelligent Computing, Current trends in Intelligent Computing (2 L)

AI Concepts
Introduction to AI, AI problems and Solution approaches, Fundamentals of problem solving using Search and Heuristics, Overview of Knowledge-base creation, and Intelligent Agents, Classification of AI.
(6 L)

Module II
Introduction to Soft Computing
Hard Computing vs. Soft Computing, Paradigms of Soft Computing, Real Life applications of Soft Computing (1L)

Fuzzy Logic
Classical Sets Vs Fuzzy Sets, Membership Functions, Fuzzy operations, Fuzzy Relations, Fuzzy Composition (Max-Min, Max-Product), Defuzzification, Fuzzy Inference System
(4L)

Genetic Algorithm
Introduction to different Evolutionary Algorithms:
Principle of Optimization, Traditional vs Evolutionary optimization, Genetic Algorithm:

Working Cycle of GA, Encoding, Crossover, Mutation.

(3 L)

Module III

Introduction to Artificial Neural Networks:

Biological Neuron to Artificial Neuron, Mc-Culloh Pitts Perceptron Model, Layer of Neurons, Activation Function, Artificial Learning, Types of Learning, Introduction to Back Propagation Networks, Applications of Neural Network.

(8L)

Module IV

Introduction to Cloud computing

Conventional Computing, Historical developments, Defining a Cloud, Cloud Computing reference model, Overview of Virtualization: Introduction, Types of cloud, Cloud Platforms: Amazon Web Services, Microsoft Azure, Cloud Applications

(8L)

Module V

Introduction to IOT

The IoT Paradigm, Concept of Things, IoT Hardware, IoT Protocols, IoT Architecture, enabling technologies of IoT, IoT Designing and its levels.

(8L)

Text books:

1. Madisetti Vijay and Bahga Arshdeep, Internet of Things (A Hands-on-Approach), 1st Edition, VPT, 2014**. (T1)**
2. Buyya Raj Kumar, Vecchiola Christian & Selvi S. Thamarai , Mastering Cloud Computing, McGraw Hill Publication, New Delhi, 2013**.(T2)**
3. Engelbrecht Andries P., Computational Intelligence: An Introduction, Wiley. **(T3)**

Reference Books:

1. Raj Pethuru and Raman Anupama C.,The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press**. (R1)**
2. Konar Amit, Computational Intelligence: Principles, Techniques and Applications, Springer. **(R2)**

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

POs met through Gaps in the Syllabus: P10 will be met though report-writing/presentation-based assignment

Topics beyond syllabus/Advanced topics/Design: Teaching through paper

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

CD #	Course Delivery methods
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars/ Quiz (s)
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid SEM Examination Marks	3	3	2	
End SEM Examination Marks	3	3	3	3
Assignment / Quiz (s)	3	3	3	2

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

Indirect Assessment

5 Student Feedback on Faculty
5 Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	3	2	2	1	1	1	2	1	1	1	1
2	2	3	2	1	1	2	1	1	3	1	2
3	3	1	3	3	2	1	1	2	1	1	1
4	2	3	1	1	1	1	2	1	1	1	1
5	1	2	1	1	3	1	1	1	2	1	1

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
CO5	CD1, CD2, CD3, CD4, CD5, CD7

COURSE INFORMATION SHEET

Course code: IT202
Course title: **Basic IT Workshop**
Pre-requisite(s):
Co- requisite(s):
Credits: L: 0 T: 0 P: 2
Class schedule per week: 2
Class: B. Tech
Semester / Level: IV/II
Branch: All

Course Objectives

This course enables the students:

1.	Understand and use the basic Matlab functions and understand its environment and variables
2.	Know about handling operations and advanced features like menus and toolbars
3.	Implement programs with the use of arrays, strings and graphical data representations
4.	Understand Python, Data Types, Operators, Arrays
5.	Implement Functions and loops, object oriented programming using Python

Course Outcomes

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

6.	Apply features of Matlab and algorithms to solve problems
7.	Develop application programs with the help of various tool boxes available in Matlab.
8.	Apply data analysis through graphical data representations
9.	Implement programs with the use of arrays, strings in Matlab
10.	Implement Functions and loops, using Python

Syllabus

Module I
Introduction to MATLAB and Basics Part I:

Introduction, Advantage, Disadvantage of MATLAB, MATLAB Environment, Variables and Array, Built-in Functions of MATLAB, Subarrays, Multidimensional Arrays, Data Files.

Module II

MATLAB Basic Part II:

Scalar and Array Operations, Hierarchy of Operations, Introduction to Plotting, Polar Plots, Subplots, MATLAB profiler. String Functions, Complex Data, Three-Dimensional Plot

Module III

MATLAB Advanced Features:

Sparse Arrays, Cell Arrays,Structure Arrays, I/O Functions, Object Handles, Position and Units, Graphical User Interface: Dialog Boxes, Menus, Toolbars.

Module IV

Introduction to Python Basics

Basics, I Python, Data Types, Operators, Arrays, Plotting

Module V

Python Programming Part 2:

Functions and loops, object oriented programming, Numerical Formalism

Sample list of Assignments:

Sample Assignments on Python Lab

Assignment 1: Data Types, Input- Outputs, Variables

4. Write a program in Python to swap two variables.

5. Write a program in Python to check the input character is an alphabet or not. Loop

6. Write a program in python to shuffle a deck of card using the module random and draw 5 cards.

7. Write a program in python to find the factors of a number.

Lab Assignment 2: Array and Lists

3. Write a program in python to transpose a given matrix M = [[1, 2], [4, 5], [3, 6]].

4. Write a program in python to print the median of a set of numbers in a file.

Lab Assignment 3: Function

6. Write a function in Python to find the resolution of a JPEG image.

7. Write a program in python and use in-built functions to convert a decimal number to binary, octal and hexadecimal number.

8. Write a program in python to sort words in alphabetical order.

Lab Assignment 4: Plot

9. Use Matplotlib to draw histogram to represent average age of population given as Age [21, 54, 66, 44, 32,42, 54, 62, 93, 45, 32, 70]
10. Create a 3-D plot in Python for the function $\sqrt{\ ^2 - \ ^2}$ over the interval $-3 \leq x \leq 3$ and $-3 \leq x \leq 3$.

Sample Assignments on MATLAB Lab Assignment

5: Assignment Statements:

1. Given two sides a= 3.2 and b=4.6 of a triangle and angle theta= 600 between these two sides. Find the length of the third side and the area of the triangle.

2. Write a MATLAB statement to calculate the sum of the series:

3. The array A is given below. Extend the 2-D array to 3-D array by including another 2-D array as second element in the third dimension.

$$\begin{matrix} 1 & & 2 & 3; \\ = 5 & & 4 & 3; \\ 1 & & 3 & 6; \end{matrix}$$

4. Let a matrix A of size (3x4) is defined as, $=$ into matrix B of the size (6x2).

5. Let a column vector z be given as z = [2; 3; 4; 5].

(i) Form a diagonal matrix A, using the elements of z as he main diagonal elements of A.

(ii) Form the matrix B, using the elements of vector z as elements of upper diagonal of B.

(iii) Form the matrix C, using the elements of vector z as elements of first lower diagonal of C.

$$\begin{matrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 7 & 8 \\ 9 & 10 & 11 & 12 \end{matrix}$$. Reshape the matrix A

6. Integrate the polynomial y = 4x3 + 12x2 + 16x + 1. Take the constant of integration as 3.

7. Find the polynomial of degree 2 to fit the following data:

x	0	1	2	4
y	1	6	20	100

Lab Assignment 8: Input-Output statement and files

8. Write a program in MATLAB to illustrate the use of 'pause' command.
9. Write a program in MATLAB to illustrate the use of fwrite function for writing binary data of different formats to a file named 'check.txt'.

Lab Assignment 9: Plots

10. Plot the curve given by the equation y = sin(x) where x varies from 0 to 2π. Also label the x-axis and y-axis and provide a suitable title for the plot

11. Plot a bar graph for the data given as x = [1 2 3 4 5 6] and y = [10 15 25 30 27 19]

12. Given x = t2 and y = 4t for -4 < t < 4. Using MATLAB obtain a 3-D plot showing the matrix in (x, y) space as a factor of time.

Lab Assignment 10: Control structures

13. Write a program in MATLAB to find the count of even values in the given n numbers. Functions

14. Write a function in MATLAB to calculate the roots of the quadratic equation ax2 + bx + c = 0, where a, b, c are constants.

Text Books:

1. MATLAB® Programming for Engineers: Stephen J. Chapman, Thomson Corporation, 4th Edition
2. Introduction to Python for Engineers and Scientists, Sandeep Nagar, Apress, 2018

Reference Books

1. Learn Python The Hard Way, Zed A. Shaw, Addison-Wesley, Third Edition

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

POs met through Gaps in the Syllabus: N/A

Topics beyond syllabus/Advanced topics/Design: through experiments involving design/modelling of device/circuits on advanced topics

POs met through Topics beyond syllabus/Advanced topics/Design: through experiments involving design/modelling of device/circuits on advanced topics

CD #	**Course Delivery methods**
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Tutorials/Assignments
CD3	Seminars/ Quiz (s)
CD4	Mini projects/Projects
CD5	Laboratory experiments/teaching aids
CD6	Industrial/guest lectures
CD7	Industrial visits/in-plant training
CD8	Self- learning such as use of NPTEL materials and internets
CD9	Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Progressive Evaluation	(60)
Attendance Marks	12
Lab file Marks	12
Viva Marks	24
Day-to-day performance Marks	12
End SEM Evaluation	(40)
Lab quiz Marks	20
Lab performance Marks	20

Assessment Components	CO1	CO2	CO3	CO4
Progressive Evaluation	3	3	3	3
End SEM Evaluation	3	3	3	3

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

Indirect Assessment

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1,CD6
CO2	CD1, CD6,CD7
CO3	CD1, CD2, CD3,
CO4	CD1, CD3,CD6,CD7
CO5	CD1,CD2,CD7

Course Outcome #	Program Outcomes										
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	3	1	3	2	1	3	1	2	
CO2	2	3	3	3	3	1	1	2	1	3	
CO3	1	3	2	1	3	1	1	1	1	1	1
CO4	2	3	3	2	2	1	1	2	1	3	
CO5	3	3	1	2	3	1	1	2	1	1	1

COURSE INFORMATION SHEET

Course code: **BE207**
Course title: **Cell Biology and Biochemistry Lab**
Pre-requisite(s): **BE202, BE204**
Co- requisite(s): **NIL**
Credits: **L: T: P: 3**
Class schedule per week: 12 per week for 1.5 months
Class: **BTech**
Semester / Level: **III rd**
Branch: Bio-Engineering
Name of Teacher:

Credit: 1.5

BE207Cell Biology and Biochemistry Lab

Experiment 1: Preparation of Buffers.
Experiment 2: Qualitative Test for Carbohydrates.
Experiment 3: Carbohydrate estimation by Anthrone.
Experiment 4: Qualitative Test for Amino Acids.
Experiment 5: Protein Estimation by Bradford Method.
Experiment 6: Protein Estimation by Lowry Method.
Experiment 7: Isolation and Estimation of DNA.
Experiment 8: Protein precipitation and purification SDS PAGE.
Experiment 9: Preparation of slides of mitosis from onion root tip cells.
Experiment 10: Study of different types of cells in the human blood smear.
Experiment 11: Identification of Barr bodies in the human cheek cells.
Experiment 12: To study the effect of plasmolysis and deplasmolysis in onion peel.
Experiment 13: To study the working of Compound microscope.
Experiment 14: To measure the length and breadth of the given cell sample by using micrometer.
Experiment 15: To identify the number of cells present in the given 1ml sample with help of haemocytometer.
Experiment 16: To identify the different types cells present in the leaf cross section.

Book

1. **Gerczei Fernandez, Timea / Pattison, Scott:** Biochemistry laboratory manual for undergraduates: An inquiry-based approach
2. **Arun Rastogi**: Laboratory Manual in Biochemistry

Course Outcomes

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

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

1.	Apply knowledge of biotechnology, inculcate acknowledge of various issues related to biotechnological techniques. Evaluate the limitations of and troubleshoot experimental approaches.
2.	Design and conduct experiments, as well as to analyze and interpret data of different biotechnological methods.

3.	identify, formulate, and solve problems arisen due to the inefficient functioning of the systems in life sciences.
4.	Use the techniques, skills, and modern tools necessary for detection of the presence of biomolecules and their estimation collection and analysis of data, and interpretation of results.
5.	demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work and recognition of the need for and an ability to engage in life-long learning
6.	Compare the structure of eukaryotic cells with the structure of simpler prokaryotic cells and with the structure of viruses.
7.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

BE208 Biology of Immune System

Course code: **BE208**
Course title: **Biology of Immune System**
Pre-requisite(s): **NIL**
Co- requisite(s): **NIL**
Credits: **L:3 T:0 P:0**
Class schedule per week: 3
Class: **B. Tech**
Semester / Level: **IIIrd**
Branch: **Biotech**
Name of Teacher:

Course Objectives

This course enables the students:

1.	To provide a thorough understanding of various Immunological phenomenon occurring in the body to fight the entry of the antigen.
2.	To provide a thorough understanding of diversity of the antibodies and the different antigen and antibody reactions used for diagnosis of the various diseases.
3.	To provide students with a deep insight about the different immunological diseases.
4.	To teach our students to have a concrete knowledge about the types of vaccines and how are they made.
5.	To acquire in-depth knowledge of immunology, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes

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

CO1	To apply knowledge of immunology, inculcate a knowledge of various issues related to immunology eg. vaccines etc. and immunological techniques.
CO2	To design and conduct experiments, as well as to analyze and interpret data of different immunological methods.
CO3	To identify, formulate, and solve problems arisen due to the inefficient functioning of the immune system.
CO4	To use the techniques, skills, and modern tools necessary for detection of the immunological diseases, design a immunology research project, collect and analyze data, and interpret results
CO5	to demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work are cognition of the need for and an ability to engage in life-long learning

BE208 Biology of Immune System

Credits:3

Module-1: Basic Concepts in Immunology: [8]
The immune system, innate and acquired immune system, components of immune system, role of humoral and cell-mediated immunity, Antibodies, the genetic basis of antibody diversity, structure-function, immunoglobulin classes. Polyclonal and Monoclonal antibodies, Catalytic antibodies.

Module-2: Antigen-Antibody Interaction: **[8]**
Structure and properties of antigens, biological aspects of antibody-antigen interaction. Identification and measurement of antibodies and antigens, Radial Immuno diffusion, Ouchterlony, Double diffusion, Immuno-electrophoresis, Radio Immunoassay, ELISA, Western blot, Immunofluorescence, Comet Assay.

Module-3: Immunological Response: [8]
Immune response, effector mechanisms, cytokines- Role of Cytokines in the Regulation of B Cells, Components of the Complement System.

Module-4: Major Histocompatibility Complex: [8]
Immunology of Transplantation, Immunology of Graft Rejection, MHC proteins, types, Concept and types of vaccines.

Module-5: Immunological disorders: [8]
Immunological disorders and Hypersensitivity: Immunodeficiency and autoimmunity, Types of hypersensitivity.

Text books:

T1. Kuby Immunology. W. H. Freeman & Co.
T2. Jareway et al, Immunology, the immune system in health and disease
T3. Cellular and molecular immunology, by Abul Abbas, Andrew Lichtman, and Jordan Pober. W. B. Saunders

Reference books:

R1. Roitt, Essential Immunology

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	10			
End Sem Examination Marks	√	√	√	√	√
Assignment*		√	√	√	√
Quiz I	√	√	√		
Quiz II				√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3										
2	3		3	3	3							
3	3				3		2					
4		3		3			2	2				
5						2			2	2		1

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: **BE 209**
Course title: **Fluid mechanics and heat transfer**
Pre-requisite(s): **Nil**
Co- requisite(s): **Nil**
Credits: **L: 3 T: 0 P:0**
Class schedule per week: 03
Class: **B. Tech**
Semester / Level: **IV/2**
Branch: **Biotechnology**
Name of Teacher:
Course Objectives

This course enables the students:

1.	To acquire a sound knowledge on fluid properties
2.	Dynamic characteristics of fluid flow for through pipes
3.	Flow measurement devices
4.	To learn heat transfer by conduction, convection and radiation

Course Outcomes

After the completion of this course, students will be:

1.	Understand the fundamental properties of fluids
2.	Analyze flow of fluid through pipe
3.	Understand and select flow meter(s) used in chemical process industries
4.	Understand the fundamentals of heat transfer mechanism

BE209 Fluid Mechanics and Heat Transfer

Credit: 3

Module-1: Basic Equations of Fluid Flow: **[8]**
Fluid-Flow Phenomena, Newtonian and non-Newtonian fluids, Turbulence and its nature, Reynolds number and transition from laminar to turbulent flow, flow in boundary layers, boundary layer formation in straight tubes, continuity equation, Bernoulli equation with and without fluid friction, pump work in Bernoulli equation.

Module-2: Flow of Incompressible Fluids: **[8]**
Fluid flow in pipes, friction factor, laminar flow in pipes, Hagen-Poiseuille equation, turbulent flow in pipes and closed channels, effect of roughness, friction factor charts, Reynolds numbers and friction factor relationship, friction losses from sudden expansion and contraction of cross section, flow measuring devices such as venturimeter, orifice meter, pitot tube and rotameter.

Module-3: Heat Transfer by Conduction in Solids: **[8]**
Fourier's Law, thermal conductivity, Steady state conduction, compound resistance in series, heat flow through a cylinder, one dimensional unsteady state heat conduction.

Module-4: Heat Transfer by Convection: **[8]**
Thermal boundary layer, Heat transfer by forced convection in laminar and in turbulent flows, heat transfer by natural convection in laminar flow, heat transfer from condensing vapors, film wise and dropwise condensation.

Module-5: Radiation Heat Transfer: **[8]**

Fundamental facts concerning radiation, emission of radiation, black body radiation, absorption of radiation by opaque solids, Kirchhoff's Law, radiation between surfaces, view factors, combined heat transfer by conduction-convection and radiation.

Text Books :

T1. McCabe, Smith and Harriot, Unit Operation of Chemical Engineering
T2. Fox and McDonald, Introduction to fluid mechanics
T3. Hollman, Heat transfer, 8th Ed.
T4. Geankoplis, Transport processes and unit operations

Reference books:

R1. White, F.M., "Fluid Mechanics ", IV Edition, McGraw-Hill Inc., 1999.
R2. Coulson, J.M. and Richardson, J.F., "Chemical Engineering " Vol. I, 4th Edn., Asian Books Pvt. Ltd., India, 1998.

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	√	√				√
End Sem Examination Marks	√	√	√	√	√	√
Assignment*		√	√	√	√	√
Quiz I	√	√	√			
Quiz II				√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	3	3	2						
2		3	3	3	3							
3		3	3					2	2	2		
4		3	3	3	3	2				2	2	

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1,2,3,4	CD1
CD2	Tutorials/Assignments	CO2,3	CD1 and CD8
CD3	Seminars	CO2	CD1 and CD2
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: **BE210**
Course title: **Thermodynamics of Chemical & Biological Systems**
Pre-requisite(s): **NIL**
Co- requisite(s):- **NIL**
Credits: 3 **L: 03 T:0 P:0**
Class schedule per week: 03
Class: **B. Tech**
Semester / Level: **IV/2**
Branch: **Biotechnology**
Name of Teacher:

Course Objectives

This course enables the students:

1.	To design, calculate and different thermodynamic parameters of chemical and biological system and interpreting experimental data.
2.	To understand the concept basic of thermodynamics principle and energy conversion and discrimination of analytical data
3.	To develop expertise and learn major concepts on applications of thermodynamics on chemical as well as biological systems.
4.	To develop knowledge pertaining to analyze thermodynamic basics for any biological pathway.
5.	Students will be able to understand the solution theory.
6.	To expand skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
7.	A clear understanding of thermodynamics concepts prepares a student for making a career as R&D expert/ analyst/ quality control manager/ product development manager etc.
8.	Students are able to search, select, organize and present information related to thermodynamics of any complex chemical and biological system.

Course Outcomes

After the completion of this course, students will be:

CO1	An ability to design, calculate and different thermodynamic parameters of chemical and biological system and interpreting experimental data.
CO2	An ability to analyze a system, component, or process to performing research in chemical/biological system and addressing the challenges associated with the complex chemical/biological system. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
CO3	An ability to apply the knowledge of various types of industrially used complex solution, metabolic pathways and enzymes modelling.
CO4	An ability to understand, design and application of the processes of molecular transition, energy analysis of any system.
CO5	An ability to prepare a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in governmental and private agencies in multidisciplinary teams. An ability to identify, formulate, and solve engineering problems.

(BE210) Thermodynamics of Chemical & Biological Systems

Credits :3

Module-I: **[8]**

Continuum and Macrose approach, Systems, control volume, intensive and extensive properties, Thermodynamic equilibrium, State of system, state diagram, path and process, Zeroth law Thermodynamics, concept of temperature, Heat and work conversion, Specific Heats.

Module-II: **[8]**

Thermodynamic properties of pure substances in solid, Liquid and vapour phases, Equations of state, Thermodynamic property table and charts. First law of Thermodynamics: Energy and its forms, Enthalpy, Compressibilities and expansion coefficient, First law applied to control volumes (Open System) – Steady & Unsteady flow analysis. Typical applications.

Module-III: **[8]**

Corollaries of Second Law – Reversible and irreversible processes, Thermodynamic (absolute) temperature scale, Inequality of Clausius and concept of Entropy. Cycles:Vapour power cycles – Carnot, Rankine, Air-Stand Cycles –Diesel Cycles.

Module- IV: **[8]**

Vapour compression refrigeration cycle. Gibbs – Duhem equation, phase rule, single component phase equilibria. Thermodynamics of solutions. Ideal and non-ideal solutions. Estimation and determination of activity coefficients, Chemical Homogenous and heterogeneous reaction systems.

Module-V: **[8]**

Thermodynamic analysis of Classical and non-equilibrium biochemical reactions: Glycolysis cycle, TCA cycle, Helix-coil transition, coupled reaction.

Books Recommended:

Text Books

T1. P.K. Nag, Thermodynamics

T2. Wylen, Fundamentals of classical thermodynamics.

T3. Denbigh, Principles of chemical equilibria

Reference books:
R1. Dodge, Chemical engineering thermodynamics

R1. Stephanoponlos et al, Metabolic engineering, Principles and Methodologies.

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training

Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√
Assignment*		√	√	√	√
Quiz I	√	√	√		
Quiz II				√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	√	√		√	√	√	√		√	√		
2		√	√		√		√	√	√	√		
3	√	√		√	√	√	√	√	√	√		
4	√	√		√	√	√	√	√		√		√
5	√	√		√	√	√	√	√		√	√	√

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8, CD9
CD4	Mini projects/Projects	CO4	CD1, CD2, CD3, CD8, CD9
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD3, CD8, CD9
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code:	**BE211**
Course title:	**Microbiology and Immunology Lab**
Pre-requisite(s):	**Basic Knowledge of microbiology and Immunology**
Co- requisite(s):	
Credits:	L: 0 T: 0 P:1.5
Class schedule per week:	3
Class:	B.Tech
Semester / Level:	III
Branch:	Biotechnology
Name of Teacher:	

Course Objectives

This course enables the students:

A.	To learn the fundamental principles of microbiology and immunology lab practices.
B.	To impart the knowledge on microbial techniques and its application.
C.	To understand the concept of antigen-antibody interaction-based techniques & its application to detect the various disease conditions.

Course Outcomes

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

1.	To demonstrate experimental skill of microbiology and immunology as well as competence in laboratory techniques.
2.	To develop the proficiency in handling, culturing, identification of microorganism and its further uses.
3.	To demonstrate the experimental skill required to identify the antigen or antigen by various techniques.
4.	To design and conduct the research in the field of microbiology and immunology and may explore the further applications.

BE211 Microbiology and Immunology Lab

Credit: 1.5

Experiment 1: Cleanliness, media preparation, sterilization, dilution techniques and isolation of pure cultures – techniques.

Experiment 2: Staining techniques in microbiology; Identification of unknown bacteria by biochemical tests.

Experiment 3: Bacterial growth curve – serial dilution plating and turbidity measurement.

Experiment 4: Extracellular enzymatic activities of microbes.

Experiment 5: Standard qualitative analysis of water.

Experiment 6: Antibiotic sensitivity test.

Experiment 7: To detect the blood group of the given sample.

Experiment 8: To perform the Technique of Radial immunodiffusion.

Experiment 9: To learn and perform the technique of Ouchterlony Double Diffusion Technique.

Experiment 10: To perform the pregnancy test with the help of Pregnancy Kit.

Experiment 11: To learn the technique of Immunoelectrophoresis.

Experiment 12: To study the technique of Rocket Immunoelectrophoresis for

determination of concentration of antigen in unknown sample.

Experiment 13: To perform widal test for detection of typhoid.

Experiment 14: To perform the sandwich Dot ELISA Test for antigen detection.

Experiment 15: To identify cells in a blood smear.

Text books:

T-1: D. K. Maheshwari and R. C. Dubey, Practical Microbiology. S. Chand.

T-2: Frank C. Hay and Olwyn M. R. Westwood, Practical Immunology. Wiley-Blackwell; 4th Revised edition

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 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

COURSE INFORMATION SHEET

Course code: **BE 212**
Course title: **Fluid Mechanics and Heat Transfer Lab**
Pre-requisite(s): **BE209**
Co- requisite(s): **NIL**
Credits: 3 **L: 3 T: 0 P:0**
Class schedule per week: 03
Class: **B. Tech**
Semester / Level: **Third**
Branch: **Biotechnology**
Name of Teacher:

This course enables the students:

1.	To acquire a sound knowledge on fluid properties
2.	Dynamic characteristics of fluid flow for through pipes
3.	Flow measurement devices
4.	To learn heat transfer by conduction, convection and radiation

Course Outcomes

After the completion of this course, students will be:

CO1	Understand the fundamental properties of fluids
CO2	Analyze flow of fluid through pipe
CO3	Understand and select flow meter(s) used in chemical process industries
CO4	Understand the fundamentals of heat transfer mechanism

BE212 Fluid Mechanics and Heat transfer lab **Credit: 1.5**

S. No	**Name of Experiments**
Experiment -1	To obtain the Reynolds number in different flow conditions.
Experiment -2	To calibrate Venturi meter and to study the variation of coefficient of discharge with the Reynolds number.
Experiment -3	To calibrate an orifice meter and to study the variation of coefficient of discharge with the Reynolds number.
Experiment -4	Calibration of Rotameter.
Experiment -5	To verify the Bernoulli's theorem experimentally.
Experiment -6	Determination of friction factor of a pipe.
Experiment -7	To study the pattern of flow in free and forced vertex.
Experiment -8	Calculate the thermal conductivity of the given liquid.
Experiment -9	Thermal conductivity of insulating powder.
Experiment -10	Calculate the heat transfer coefficient for a pipe by natural convection.
Experiment -11	Calculate the heat transfer coefficient for a pipe by forced convection.
Experiment -12	Determine the emissivity of the given material.
Experiment -13	Impact of jet on vanes (Flat and hemispherical plate).
Experiment -14	Jet pump test rig.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

COURSE INFORMATION SHEET

Course code: EE102
Course title: Electrical Engineering Laboratory
Pre-requisite(s): Physics, Fundamentals of Mathematics and Electrical Engineering.
Co- requisite(s): NIL
Credits: L:0 T:0 P: 3
Class schedule per week: 12 per week for 1.5 months
Class: BTech
Semester / Level: IVth
Branch: Bio-Engineering
Name of Teacher:

Course Overview: Concepts of measuring instruments, AC RLC series parallel circuit operation, resonance, KVL and KCL, circuit theorems, 3-phase star and delta connections, measurement of low and high resistance of D.C. machine, measurement of power by three voltmeter, three-ammeter methods, measurement of power of 3-phase induction motor by two-wattmeter method.

Course Objectives

This course enables the students:

1	To describe students practical knowledge of active and passive elements and operation of measuring instruments
2	To demonstrate electrical circuit fundamentals and their equivalent circuit models for both 1-φ and 3- φ circuits and use circuit theorems
3	To establish voltage & current relationships with the help of phasors and correlate them to experimental results
4	1. To conclude performance of 1 – Φ AC series circuits by resonance phenomena 2. To evaluate different power measurement for both 1-φ and 3- φ circuits

Course Outcomes

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

CO1	classify active and passive elements, explain working and use of electrical components, different types of measuring instruments;
CO2	illustrate fundamentals of operation of DC circuits, 1-φ and 3- φ circuits and also correlate the principles of DC, AC 1-φ and 3- φ circuits to rotating machines like Induction motor and D.C machine.;
CO3	measure voltage, current, power, for DC and AC circuits and also represent them in phasor notations;
CO4	analyse response of a circuit and calculate unknown circuit parameters;
CO5	recommend and justify power factor improvement method in order to save electrical energy.

List of Experiments:

1. **Name: Measurement of low & high resistance of DC shunt motor**
   Aim:

   (i) To measure low resistance of armature winding of DC shunt motor
   (ii) To measure high resistance of shunt field winding of DC shunt motor

2. **Name: AC series circuit**
   Aim:

(i) To obtain current & voltage distribution in AC RLC series circuit and to draw phasor diagram
(ii)To obtain power & power factor of single phase load using 3- Voltmeter method and to draw phasor diagram

3. **Name: AC parallel circuit**
   Aim:

(i) To obtain current & voltage distribution in AC RLC parallel circuit and to draw phasor diagram
(ii) To obtain power & power factor of single phase load using 3- Ammeter method and to draw phasor diagram

4. **Name: Resonance in AC RLC series circuit**
   Aim :

   (i) To obtain the condition of resonance in AC RLC series circuit
   (ii) To draw phasor diagram

5. **Name: 3 phase Star connection**
   Aim :

   (i) To establish the relation between line & phase quantity in 3 phase star connection
   (ii) To draw the phasor diagram

6. **Name: 3 phase Delta connection**
   Aim :

   (i) To establish the relation between line & phase quantity in 3 phase delta connection
   (ii) To draw phasor diagram

7. **Name: 3 phase power measurement**
   Aim :

   (i) To measure the power input to a 3 phase induction motor using 2 wattmeter method
   (ii) To draw phasor diagram

8. **Name: Self & mutual inductance**
   Aim :

   To determine self & mutual inductance of coils

9. **Name: Verification of Superposition, Thevenin's and Reciprocity theorem**
   Aim :

   (i) To verify Superposition theorem for a given circuit
   (ii) To verify Thevenin's theorem for a given circuit

10. Name: Verification of Norton's, Tellegen's and Maximum Power transfer theorem
Aim :

(i) To verify Norton's theorem for a given circuit
(ii) To verify Maximum Power transfer theorem for a given circuit

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

1. Application of principles of magnetic circuits to electrical machines like transformers, generators and motors
2. Visualize Phase sequence

POs met through Gaps in the Syllabus: 1, 2, 3, 7.

Topics beyond syllabus/Advanced topics/Design

1. Assignment : Simulation of electrical circuits with dependent/independent sources by various techniques (Mesh current/Node Voltage/Thevenin's theorem/Norton's theorem/Maximum power transfer theorem etc.) using MATLAB/PSIM/C++ softwares
2. Active/reactive power calculation for 3 – Φ circuits

POs met through Topics beyond syllabus/Advanced topics/Design: 5, 6, 7, 8, 9.

Mapping of lab experiment with Course Outcomes

Experiment	Course Outcomes				
	CO1	CO2	CO3	CO4	CO5
1	3	3	3	2	
2	3	3	3	3	2
3	3	3	3	3	2
4	3	3	3	3	2
5	3	3	3	1	
6	3	3	3	1	
7	3	3	3	2	2
8	3	3	3	3	
9	3	3	3	2	
10	3	3	3	2	

Course Delivery methods	
CD1	Lecture by use of boards/LCD projectors
CD2	Tutorials/Assignments
CD3	Mini projects/Projects
CD4	Laboratory experiments/teaching aids
CD5	Self- learning such as use of NPTEL materials and internets
CD6	Simulation

Course Evaluation:

Daily individual assessment through viva: 20

Regular evaluation of fair and rough copy: 15+5=20 Progressive evaluation (60)
Regularity/Punctuality: 10

Assignment: 10

Practical examinations: 20 }

End sem Viva-voce : 20 end evaluation (40)

TOTAL: 100

Mapping of Course Outcomes onto Course Objectives

Course Outcome #	**Course Objectives**			
	CO1	**CO2**	**CO3**	**CO4**
1	3	3	3	3
2	3	3	3	3
3	3	3	3	3
4	3	3	3	3
5	2	3	3	3

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes**											
#	1	2	3	4	5	6	7	8	9	10	11	12
1	3	3	3	3	3	L	3	3	3	3	3	3
2	3	3	3	2	2	2	2	3	3	3	3	3
3	3	3	3	2	2	2	2	2	3	3	2	3
4	3	3	3	3	3	1	2	2	3	3	2	2
5	3	3	3	3	3	2	3	3	3	3	3	3

Mapping of Course Outcomes onto Program Educational Objectives

Course Outcome	**Program Educational Objectives**			
#	1	2	3	4
1	3	3	2	2
2	3	3	3	
3	3	3	3	2
4	3	3	3	
5	H	H	M	M

Mapping Between COs and Course Delivery (CD) methods

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

Course Delivery (CD) methods		Program Outcomes (PO)											
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CD1	Lecture by use of boards/LCD projectors	2	1	1	2	3	1						
CD2	Tutorials/ Assignments	2	2	2	2	3	3			3	3	1	2
CD3	Seminars												
CD4	Mini projects/Projects												
CD5	Laboratory experiments/teaching aids	3	3	3	3	3	1		2	3	2	2	3
CD6	Industrial/guest lectures												
CD7	Industrial visits/in-plant training												
CD8	Self- learning such as use of NPTEL materials and internets	3	3	3	3	3	3	2	3	2	3	2	2
CD9	Simulation	3	3	3		3	3			2	2		

COURSE INFORMATION SHEET

Course code: BE213
Course title: Pharmaceutical Biotechnology
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 03 T:00 P:00
Class schedule per week: 03
Class: B. Tech
Semester / Level: IV/2
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	Understand the basic concepts involved in biopharmaceutical drug production, genomics and gene therapy
B.	Knowledge about therapeutic effects and side effect of biopharmaceuticals. Knowledge about new drug development procedures, drug approval, ADMET of drugs
C.	Appreciate and understand the manufacturing and quality control of drugs and legal steps involved in progressing a new drug to market
D.	Demonstrate knowledge and understanding of currently relevant and newly emerging aspects of pharmaceutical biotechnology

Course Outcomes

After the completion of this course, students will be:

1.	Students will have a basic understanding of the scientific method. explain the strategies and various steps of new drug discovery process
2.	Able to explain the concept of genomics, gene therapy, pharmacogenomics and pharmacodynamic
3.	Apply the knowledge of pharmaceutical manufacturing in the production of biopharmaceuticals like vaccines, proteins and hormones.
4.	Carry out the quality control procedures in the production of various biopharmaceuticals. Explain the economics and regulatory aspects in the development of pharmaceuticals.

Module-1: **[8]**
Molecular Biotechnology: Genomics and its impact on medicine. Molecular medicine, Rational drug design.

Module-2: **[8]**
Gene Testing & Diagnostics: Gene testing, pharmacogenomics, Molecular diagnostics.

Module-3 **[8]**
Cancer Biology & Gene therapy: Oncogenes, tumor suppressor genes, growth factors, Genetic diseases and DNA based diagnosis of genetic diseases. Gene therapy.

Module-4: **[8]**
Formulation of Biotech Products: Microbiological consideration, use of excipients, Drug delivery methods, Shelf life of biopharmaceuticals, pharmacodynamics of protein therapeutics.

Module-5: **[8]**
Genetically Engineered Pharmaceuticals: Insulins, Growth Hormones, Vaccines, Interferons & interleukins, Tissue type plasminogen activator, Economic aspects in pharmaceutical biotechnology.

Books Recommended:
Maulik and Patel, Molecular Biotechnology – Therapeutic applications and strategies.
Zito, Pharmaceutical Biotechnology
Crommelin & Sindelar, Pharmaceutical Biotechnology

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

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design: NA

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	
Mid Sem Examination Marks	10	10	**5**		**25%**
Faculty assessment			**2.5**	**2.5**	**5%**
Assignment	**5**	**5**	**5**	**5**	**20%**
End Sem Examination Marks	**10**	**20**	10	10	**50%**
					100%

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3									
2	3	3		3	3	3	2					
3			3	3	3	3	2	2				
4							2	2				3

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: **BE214**
Course title: **Natural Product Biotechnology**
Pre-requisite(s): **BE 204 Biochemistry and Enzyme Technology**
Co- requisite(s): **Nil**
Credits: L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: IV/II
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

A.	establish an understanding of the major classes of phyto-chemicals, pathways for biosynthesis and production phytochemicals in nature.
B.	expose students with different methods of isolation, purification and characterization of phytochemicals.
C.	give them knowledge about separation of phytochemicals and analysis of plant materials.
D.	expose students with different methods of production of biotech natural products at laboratory as well as industrial level.

Course Outcomes

After the completion of this course, students will be:

1.	Able to know about the major classes of phytochemicals.
2.	Able to know about the major pathways for biosynthesis and production phytochemicals in nature.
3.	Able to know about the issues related to phytochemicals such as isolation, purification and characterization of phytochemicals.
4.	They will be able to outline the analytical operations of phytochemical purification and characterization.
5.	They will be able to design the steps of production phytochemicals at laboratory and industrial scale.

Syllabus

Module-1: **[8]**
Natural Substances: Sources, Cultivation and Production; Interrelationships of Drug Biosynthetic Pathways, Phytochemical classification of drugs.

Module-2: **[8]**
Biosynthesis of Natural Product: Glycosides -shikimic acid and phenylalanine pathways, Terpenoids-Monoterpenoids, Alkaloids-Ephedrine, Biosynthesis of Phenylpropanoids via the Shikimic Acid Pathway

Module-3: **[8]**

Analysis of Natural Products: Extraction by aqueous and solvent methods, purification by TLC, HPTLC, HPLC, characterization by mass and NMR spectrometry; Plant metabolomics.

Module-4: **[8]**

Production of Biotech Natural Products: Biotransformation of plant metabolites, Transgenic plants, Large scale plant cell culture. Details of methods of production of biotech natural products e.g. Potato Vaccine, Functional Food, Contemporary Nutraceuticals-Spirulina, Omega-3 Fatty Acids.

Module-5: **[8]**

Biopharmaceuticals: Ginseng, Ephedrine, Artemicinin, Taxol and Shikonin production by cell culture methods.

Recommended Books

1. 'Pharmacognosy and Pharmacobiotechnology- Ashutosh Kar
2. Plant Biotechnology: Recent Advancements and Developments- Gahlawat, S.K., Salar, R.K., Siwach, P., Duhan, J.S., Kumar, S., Kaur, P. (Eds)

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors ✓
Tutorials/Assignments ✓
Seminars ✓
Mini projects/Projects✓
Laboratory experiments/teaching aids ✓
Industrial/guest lectures✓
Industrial visits/in-plant training✓
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	10	15			
Faculty Assessment				**2.5**	**2.5**
End Sem Examination Marks	8	12	10	10	10
Assignment / Quiz (s) (2 No.)	**4**	6	4	3	3

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3					2						
2	3					2						2
3	3	3	3		2	2						2
4	3	3	3	2		2						
5	3	2	3	2		2	2	2			2	

COURSE INFORMATION SHEET

Course code: **BE215**
Course title: **Cellular Electrophysiology**
Pre-requisite(s): **Basic on cell biology**
Co- requisite(s): **Basic electrical measurement**
Credits: 3 **L: 3 T: 0 P: 0**
Class schedule per week: **03**
Class: **B. Tech**
Semester / Level: **IV/2**
Branch: **Biotechnology**
Name of Teacher:

Course Objectives

This course enables the students:

1.	To impart knowledge for interdisciplinary, applied engineering and technology.
2.	To understand basic cellular electrical characteristics.
3.	To learn and correlate the technicality associated with cell electrophysiology with electrical components and circuits.
4.	To record and analyse the electrophysiological characteristics of living system.

Course Outcomes

After the completion of this course, students will be:

CO1	Understand 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	Understand and create a model of dynamics of receptor physiology in diseases.

Cellular Electrophysiology

Credits :3

Module-1: **[8]**

Current-voltage curves for voltage-gated ion channels: generation and analysis. Ca channel I-V curves: Goldman equation. Input resistance: theory, measurement, inferencing; Applications to skeletal and smooth muscle. Extensions of cable theory: predictions of cable equation; finite cables.

Module-2: **[8]**

Origin of biopotentials: resting membrane potential; Nernst potentials. Selective permeability and the Donnan equilibrium; Goldman-Hodgkin-Katz equation. Action potentials: ionic basis, properties of generation and conduction, examples in different cell types. Intracellular and extracellular recording: biophysical outcomes.

Module-3: **[8]**

Action potential of excitable cells: Quantitative description, Hodgkin-Huxley model, significance of parameters in Hodgkin-Huxley equations; Voltage-clamp experiments: design, and analysis of results; Factors determining the initiation, amplitudes, and kinetic properties of action potentials.

Module-4: **[8]**

Passive membrane electrical properties: Cellular resistance, capacitance, time constant and space constant, methods of measurement; Importance in cellular excitation and signaling: Impulse propagation.

Module-5: **[8]**

Electrophysiology of synaptic transmission: Prejunctional and postjunctional electrical events; time courses of transmitter-activated membrane currents and potentials in skeletal and smooth muscle; Electrical models of the skeletal and smooth muscle membranes.

Text Books:

T1. Guyton, A.C. Medical physiology, 8th/ 9thIntnl Edn., Philadelphia, W.B. Saunders, 2001/2006.

T2. E.R. Kandel& J. Shwartz (ed.) : Principles of Neural Science, 3rd ed., 1991.

T3. Methods in neuronal modeling: from ions to networks; Eds C. Koch, I. Segev. Cambridge: MIT Press 1998.

T4. Computational neuroscience: realistic modeling for experimentalists; Ed: De Schutter, E. Boca Raton: CRC Press 2001

T5. Foundations of cellular neurophysiology; Johnston, D., Wu, S. Cambridge: MIT Press, 1995.

Reference Books:

R1. B. Katz : Nerve, Muscle, and Synapse, Mc-Graw Hill, New York, 1966.

R2. J.G. Nicholls, A.R. Martin & B. Wallace: From Neuron to Brain, 3rd ed., Sinauer, Sunderland, 1992.

R3. J.J.B. Jack, D. Noble & R.W. Tsien: Electric Current Flow in Excitable Cells, Oxford University Press, 1983.

R4. R.D. Barr & R.L. Plonsey: Bioelectricity: A Quantitative Approach, Academic Press, N.Y., 1988.

R5. The Physiology of Excitable Cells by D. J. Aidley, Cambridge Press, UK.

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: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

1. Lecture on specialised techniques in electrophysiological recordings
2. Lecture on specialized electrophysiological devices

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	10			
End Sem Examination Marks	√	√	√	√	√
Assignment*		√	√	√	√
Quiz I	√	√	√		
Quiz II				√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3		3									

2	3	3										
3	3		3		3							
4	3	3	3			2						
5		3	3			2	2					

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3, CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO4, CO5	CD5

COURSE INFORMATION SHEET

Course code: **BE 216**
Course title: **Enzyme Technology**
Pre-requisite(s):
Co- requisite(s):
Credits: **3** **L: 3** **T: 0** **P:0**
Class schedule per week: **3**
Class: **B.Tech.**
Semester / Level: **IV/2**
Branch: **Biotechnology**
Name of Teacher:

Course Objectives

This course enables the students:

1.	To learn the fundamental principles of enzyme technology.
2.	To impart the knowledge on enzyme kinetics and its application in industrial bioprocess development.
3.	To understand the use of enzyme as tool in the field of pharmaceutics and agriculture.

Course Outcomes

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

CO1	To apply the engineering principles to produce, purify and manipulate the enzyme for various industrial processes.
CO2	To comprehend the various methods of clinical practices and green chemical process and can design the sustainable bioprocess using the enzymes.
CO3	To analyze a research problem and write clear, step-by-step instructions for conducting experiments or testing hypothesis.

BE216 Enzyme Technology

Credit: 3

Module-1: Introduction to Enzymes and Enzyme Models: [8]
Chemical nature and properties of enzymes. Energy of activation, Enzyme activity, types of enzyme specificities, enzyme substrate reactions. Lock and key hypothesis induced fit hypothesis, Multi-substrate reactions, Allosteric enzymes, Isoenzymes, Multienzyme complex, and multifunctional enzymes.

Module-2: Enzyme Kinetics: [8]
Covalent catalysis, acid base catalysis, metal ion catalysis with mechanism. Kinetics of single substrate, multi-substrate, reversible and allosteric enzymes. Enzyme inhibition-competitive, uncompetitive and noncompetitive inhibition. Enzyme deactivation kinetics, factors affecting enzyme kinetics.

Module-3: Screening, Extraction, Purification and Characterization of Enzymes: [8]

Screening for novel biocatalysts, enzyme assay, general procedures for isolation and selection of microorganisms involved in enzyme production, high-throughput screening, strategies of extraction and purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes. Creation of tailor-made biocatalyst.

Module-4: Immobilization of Enzymes and Methods of Enzyme Stabilization: [8]

Methods of enzyme immobilization, production and application of free and immobilized enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics. Kinetics of immobilized enzymes. Stability of enzymes: Enzyme stabilization by selection and genetic engineering, protein engineering, reaction environment rebuilding.

Module-5: Clinical and Industrial Applications of Enzymes: [8]

Importance of enzymes in diagnostics-use of enzymes to determine the concentration of metabolites of clinical importance, Determination of enzyme activities for clinical diagnosis. Detection of inborn errors by the assay of enzymes, use of microorganisms in the production of organic chemicals, use of enzymes in industrial processes.

Text books:

T-1: Lehninger, Nelson, Cox, Principles of Biochemistry.
T-2: Enzyme by Palmer (2001); Horwood publishing series

Reference books:

R-1: Godfrey and West, Industrial enzymology

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	20
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3
Mid Sem Examination Marks	√	10	
End Sem Examination Marks	√	√	√
Assignment*		√	√
Quiz I	√	√	√
Quiz II		√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	3	3	2	2			1		1
2	3	3	3	3	3	2	2	2	1	1	2	1
3	3	3	3	3	3	2	2	2	1	1	2	1

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD7
CD3	Seminars	CO3	CD1, CD2, CD8
CD4	Mini projects/Projects		
CD5	Laboratory experiments/teaching aids		
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: MA 203
Course title: Numerical Methods
Pre-requisite(s): NIL
Co- requisite(s):--NIL
Credits:2 L: 2 T: 0 P: 0 C: 2
Class schedule per week: 2 Lectures
Class: B Tech
Semester/ Level: 2
Branch: ALL
Name of teacher:

Course Objectives: This course enables the students to

1.	derive appropriate numerical methods to solve algebraic and transcendental equations
2.	derive appropriate numerical methods to solve linear system of equations
3.	approximate a function using various interpolation techniques
4.	to find the numerical solution of initial value problems and boundary value problems

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

C01	solve algebraic and transcendental equation using an appropriate numerical method arising various engineering problem
C02	solve linear system of equations using an appropriate numerical method arising in computer programming. Chemical engineering problems etc.
C03.	Approximate a function using an appropriate numerical method in various research problems
C04	evaluate derivative at a value using an appropriate numerical method in various research
C05	solve differential equation numerically

MA203 **Numerical Methods** **2-0-0-2**

Module I: Errors and Nonlinear Equations

Error Analysis: Definition and sources of errors, propagation of errors, floating-point arithmetic Solution of Nonlinear equations: Bisection method, Regula-Falsi method, Secant method, Newton-Raphson method and its variants, General Iterative method. [05L]

Module II: System of Linear Equations

Gauss-Elimination, Gauss-Jordan, LU-Decomposition, Gauss-Jacobi and Gauss- Siedel methods to solve linear system of equations and Power method to find least and largest eigenvalues. [05L]

Module III: Interpolation

Lagrange's interpolation, Newton's divided differences interpolation formulas, inverse interpolation, interpolating polynomial using finite differences. [05L]

Module IV: Differentiation and Integration

Differentiation using interpolation formulas, Integration using Newton-Cotes formulas: Trapezoidal rule, Simpson's rule [05L]

Module V: Solution of Ordinary Differential Equations

Euler's method, modified Euler's method, Runge – Kutta Methods of second and fourth order to solve initial value problems. [05L]

TextBooks:

1. Jain M.K, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, New Age Publications, 2004.
2. S.S. Sastry, Introductory Methods of Numerical Analysis, PHI.
3. E. Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.

Reference Books:

1. S.C. Chapra and R. P. Canale, Numerical Methods for Engineers, McGraw Hill, 1985.
2. C.F. Gerald and P.O. Wheatley, Applied Numerical Analysis, Pearson Education, Seventh Edition, 2003.
3. R. W. Hamming: Numerical Methods for Scientists and Engineers, Second Edition, Dover

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓
Seminars	
Mini projects/Projects	✓
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	✓
Simulation	

Course outcome (co) attainment assessment tools & evaluation procedure Direct assessment

Assessment tool	% contribution during co assessment
Mid semester examination	25
End semester examination	50
Quiz (s)	10+10
Assignment	5

I. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

Course outcome #	Program outcomes											
	PO1	P02	P03	P04	POS	P06	P07	P08	P09	PO10	PO11	P012
1	3		2		1	1	1	1	3	3	2	2
2	3		2		1	1		1	3	3	2	2
3	3		2		1	1	1	1	3	3	2	2
4			3	1	1	1	1	1	3	3	2	2
5			3	3	1	2	1	1	3	3	2	2

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

COURSE INFORMATTON SHEET

Course code: MA 204
Course title: Numerical Methods Lab
Pre-requisite(s): NIL
Co- rcquisite(s): - NlL
Credits:1 L: 0 T: 0 P: 2
Class schedule per week: 2 Sessional
Class: BE
Semester /Level: III UG
Branch: ALL Name of Teacher:

List of Assignment

1. Find a simple root of $f(x)=0$ using bisection method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
2. Find a simple root of $f(x)=0$ using Regula-Falsi method. Read the end points of the interval (a,b) in which the root lies, maximum number of iterations n and error tolerance eps.
3. Find a simple root of $f(x)=0$ using Newton Raphson method. Read any initial approximation x_0, maximum number of iterations n and error tolerance eps.
4. Solution of a system of $n\times n$ linear equations using Gauss elimination method with partial pivoting. The program is for 10×10 system or higher order system.
5. Matrix inversion and solution of $n\times n$ system of equations using Gauss-Jordan method. If the system of equations is larger than 15×15 change the dimensions of the float statement.
6. Program to solve a system of equation using Gauss-Seidel iteration method. Order of the matrix is n, maximum number of iterations $niter$, error tolerance is eps and the initial approximation to the solution vector is x_0. If the system of equations is larger than 10×10 change the dimension in float.
7. Program to find the largest Eigen value in magnitude and the corresponding Eigen vector of a square matrix A of order n using power method.
8. Program for Lagrange interpolation.
9. Program for Newton divided difference interpolation.
10. Program for Newton's forward and backward interpolation.
11. Program for Gauss's central difference interpolation (both backward and forward).
12. Program to evaluate the integral of $f(x)$ between the limits a to b using Trapezoidal rule of integration based on n subintervals or $n+1$ nodal points. The values of a,b and n are to be read. The program is tested for $f(x)=1/(1+x)$.
13. Program to evaluate the integral of $f(x)$ between the limits a to b using Simpson's rule of integration based on $2n$ subintervals or $2n+1$ nodal points. The values of a,b and n are to be read and the integrand is written as a function subprogram. The program is tested for $f(x)=1/(1+x)$.
14. Program to solve an IVP, $dy/dx=f(x), y(x_0)=y_0$ using Euler method. The initial value x_0, y_0 the final value x_f and the step size h are to be read. The program is tested for $f(x,y)=-2xy^2$.
15. Program to solve an IVP, $dy/dx=f(x), y(x_0)=y_0$ using the classical Runge-Kutta fourth order method with step size h, $h/2$ and also computes the estimate of the truncation error. Input parameters are: initial point, initial value, number of intervals and the step length h. Solutions with h, $h/2$ and the estimate of the truncation error are available as output. The right hand side The program is tested for $f(x,y)=-2xy^2$.

COURSE INFORMATION SHEET

Course code: MT123
Course title: Business Communications
Pre-requisite(s):
Co- requisite(s):
Credits:3 L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: V/1
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To analyze and demonstrate writing and speaking processes through invention, organization, drafting, revision, editing, and presentation.
B.	To understand the importance of specifying audience and purpose and to select appropriate communication choices.
C.	To interpret and appropriately apply modes of expression, i.e., descriptive, expositive, Narrative, scientific, and self-expressive, in written, visual, and oral communication
D.	To participate effectively in groups with emphasis on listening, critical and reflective thinking, and responding.
.E	To develop the ability to research and write a documented paper and/or to give an oral presentation.

Course Outcomes

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

1.	Apply business communication strategies and principles to prepare effective communication for domestic and international business situations.
2.	Utilize analytical and problem-solving skills appropriate to business communication.
3.	Participate in team activities that lead to the development of collaborative work skills.
4.	Select appropriate organizational formats and channels used in developing and presenting business messages
5.	Communicate via electronic mail, Internet, and other technologies and deliver an effective oral business presentation.

Syllabus

MT123: Business Communication

Credits: 3

Module I **[8]**

Introduction to Business Communication:

Importance and Objectives of Business communication, Process of communication, Barriers to effective communication, Techniques of effective communication. Forms of communication (Written, Oral, audio-visual communication).

Module II **[8]**

Managing Business Communication:

Formal and Informal communication, Non- verbal communication (Body language, Gestures, Postures, Facial expressions). The cross cultural dimensions of business communication. Techniques to effective listening, methods and styles of reading.

Module III **[8]**

Other aspects of communication:
Vocabulary:
Single word substitution, Idioms and phrases, Precis writing, Comprehension.
Group Discussions, Extempore, Principles of effective speech and presentations, Role playing.

Module IV: **[8]**

Introduction to managerial writing:

Business letters: Inquiries, Circulars, Quotations, Orders, Acknowledgement, Claims & adjustments, Collection letters, Sales letters, Drafting of different resumes, Covering letters Applying for a job, Social correspondence, Invitation to speak.

Official Correspondence: Memorandum, Notice, Agenda, Minutes, Circular letters.

Module V: **[8]**

Report writing:

Business reports, Types, Characteristics, Importance, Elements of structure, Process of writing, Order of writing, the final draft, check lists for reports.

Text Books:

T1. Communication Skills, Sanjay Kumar &PushpLata, Oxford University Press
T2. Business Correspondence and Report Writing,R.C.Sharma, Krishna Mohan.Mcgraw Hill
T3. Communication for Business,Shirley Taylor, V.Chandra, Pearson
T4. Business Communication- HorySankar Mukherjee, Oxford University Press
T5. Basic Business Communication- .Lesikar I Flatley, McGraw Hill.
T6. Business Communication Today ,Bovee, Thill and Chaterjee, Pearson

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Quiz(I,II)	20
Mid Term Examination Marks	25
Attendance	5
End Term Examination Marks	50

AssessmentCompoents	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Quiz(I,II)	√	√	√		
End Sem Examination Marks	√	√	√	√	√
Mid Term Examination Marks			√	√	√

Indirect Assessment –

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

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1,CD2,CD3
CD2	Tutorials/Assignments		CO2	CD1,CD2,CD3
CD3	Seminars		CO3	CD1,CD2,CD3
CD4	Mini projects/Projects		CO4	CD1,CD2,CD3,CO4 CD5

CD5	Laboratory experiments/teaching aids		CO5	CD1,CD2,CO5
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE301
Course title: Bio-analytical techniques
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: Fifth/ Third
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	Develop the ability to design and conduct experiments, including making measurements and interpreting experimental data from living system and addressing the problems associated with the interaction between living systems and nonliving materials.
B.	An understanding of the use of different instruments, discrimination of analytical data; and functions of different components of the selected instruments and their effects on data analysis.
C.	To develop expertise, an understanding of the range and theories of instrumental methods available in biological research/ biotechnology.
D.	To develop knowledge pertaining to the appropriate selection of instruments for the successful analysis of complex mixture.
E.	To provide an understanding of and skills in advanced methods of separation and analysis.
F.	To expand skills in the scientific method of planning, developing, conducting, reviewing and reporting experiments.
G.	A clear understanding of bioanalytical technique prepares a student for making a career as R&D expert/ analyst/ quality control manager/ product development manager etc.
H.	Students are able to search, select, organize and present information related to bioinstrumentation.

Course Outcomes

After the completion of this course, students will be:

1.	An ability to apply knowledge of mathematics, science, and engineering. An ability to design and conduct experiments, as well as to analyze and interpret data for related to domain of Bioinstrumentation.
2.	An ability to design a system, component, or process to performing research in biological system and addressing the challenges associated with the Centrifugation Techniques and Electro-kinetics. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
3.	An ability to apply the knowledge of various types of industrially used Chromatographic Techniques and imaging methods; advantages and disadvantages, design criteria, molecular imaging, instrumentation and various aspects of operation.
4.	An ability to understand, design and application of the processes of Spectroscopy and Thermal Analysis
5.	An ability to prepare a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in governmental and private agencies in multidisciplinary teams. An ability to identify, formulate, and solve engineering problems.

BE301 BIOANALYTICAL TECHNIQUES

Module-I

Centrifugation Techniques and Electro-kinetics: Principle, instrument and application of steady state sedimentation, density gradient centrifugation, analytical centrifugation.

Module-II

Electro-kinetics: Electro-osmosis and electrophoresis, Helmholtz-Smoluchowski equation, Zeta potential, Principle, design and application of Gel electrophoresis; SDS-PAGE, gradient gels, Two dimensional gels, isoelectric focusing.

Module-III

Chromatographic Techniques: Principles, design and application of column chromatography, partition and adsorption chromatography, Affinity Chromatography; Ion Exchange Chromatography, Gas Chromatography, HPLC

Module-IV

Spectroscopy -I: Beers Lamberts law, Principles, Instrumentation and applications of Visible and UV Spectrophotometry; Spectroflourimetry (FRET); FTIR, NMR spectroscopy.

Module-V

Spectroscopy – II and Thermal Analysis: Principles, Instrumentation & applications for flame emission / atomic absorption spectrophotometry and their comparative study; ICP (b) Mass spectrometry; Principles, Instrumentation and applications. Instrumentation and application of Differential scanning calorimetry and Thermogravimetry.

Books Recommended:

1. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.
2. Willard and Merrit, Instrumental Methods and Analysis
3. Ewing GW, Instrumental Methods of Chemical analysis.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Mid Sem Exam	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	√	√		√	√	√	√		√	√		
2		√	√		√		√	√	√	√		
3	√	√		√	√	√	√	√	√	√		
4	√	√		√	√	√	√	√		√		√
5	√	√		√	√	√	√	√		√	√	√

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8, CD9
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8, CD9
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD3, CD8, CD9
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE302

Course title: Functional Genomics and rDNA Technology

Pre-requisite(s):

Co- requisite(s): None

Credits: 3 L:3 T:0 P:0

Class schedule per week: 03

Class: BTECH.

Semester / Level: 5/03

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

A	To understand about RNA world hypothesis, application of forward and reverse genetics.
B	To learn the genetic engineering techniques used in genes regulation and genome editing mechanism
C	To get knowledge and design the experiments using various genome sequencing strategies, annotation, database development as well as their applications.
D	To learn about methods involved in cloning and expression of gene of interest, cloning and expression vectors and recombinant protein purification
E	To understand the use of rDNA Technology in the crop improvement, drug discovery, value added crops as well as development of recombinant proteins

Course Outcomes:

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

CO1	explain the application of forward and reverse genetics
CO2	Use various techniques in regulating and editing the gene for the meaningful purpose
CO3	Execute and design the experiments of genome sequencing, their subsequent analysis and preparation of database

CO4	Explain and design cloning and expression strategies of a suitable cloning vectors and their uses
CO5	Explain and design cloning and expression strategies of a candidate gene, its expression in host and its purification
CO6	develop capacity to pin point the strategies used for crop improvement, development of drug and DNA vaccine, diagnostics, recombinant proteins

BE302 Functional Genomics and rDNA Technology

Module-I **[8]**

Genomic evolution: The world of RNA, ribozyme, Genetics to genomics to functional genomics. Forward and reverse genetics, Antisense RNA, siRNA, RNA interference, miRNA, TALEN, CRISPR-Cas9

Module-II **[8]**

Genetic engineering techniques: Restriction and modifying enzymes, Various blotting techniques, PCR techniques, RT-PCR, qPCR, Digital PCR, Site directed mutagenesis, Genomic and cDNA libraries, Screening of libraries, Microarray

Module-III **[8]**

Genome sequencing: Overview of conventional and new sequencing technologies, Strategies used in whole genome sequencing, NGS technologies, RNAseq, Genome annotation, Candidate gene discover and data mining, Transcription factor, Development of databases and their uses

Module-IV **[8]**

Cloning and expression: Characteristics of plasmid and other cloning vectors, Artificial chromosomes, Prokaryotic and eukaryotic expression vectors, Methods of recombinant protein purification

Module-V **[8]**

Applications of rDNA Technology: Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis, Transgenics in industry, Transgenics in medicine, recombinant proteins and their uses.

Text book

1. *Principles of Genome analysis and Genomics*, 3rd Edition, By S. B. Primrose and R. L. Twyman, Blackwell publishing (2003), ISBN: 1405101202
2. *Bioinformatics and Functional Genomics*, 3rd Edition, By Jonathan Pevsner, Wiley-Blackwell (2015), ISBN: 978-1-118-58178-0.
3. Functional Genomics, **Methods and Protocols by** Editors: **Kaufmann**, Michael, **Klinger**, Claudia, **Savelsbergh**, Andreas (Eds.). Springer (2017) ISBN 978-1-4939-7231-9

Reference book

1. *Principles and Practices of Plant Genomics* (Volume 3), By Chittaranjan Kole and Albert G. Abbott. CRC Press (2017): ISBN 9781138116498
2. Genome Analysis: Current Procedures and Applications by Maria S. Poptsova. Caister Academic Press (2014) ISBN: 978-1-908230-29-4.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	√
Tutorials/Assignments	√
Seminars	√
Mini projects/Projects	
Laboratory experiments/teaching aids	√
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	50
Assignment / Quiz (s)	10+10
Teacher's Assessment	5

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	√	√				
End Sem Examination Marks	√	√	√	√	√	√
Quiz I	√	√	√			
Quiz II				√		√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3		3									
2	3	3	3									
3	3	2	3		3							
4	3	2				2			2	2		
5		3	3			2		2				
6				3			2					1

Mapping Between COs and Course Delivery (CD) methods			
CD	**Course Delivery methods**	**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors	CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
CD3	Seminars	CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects	CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids	CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		
CD7	Industrial visits/in-plant training		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		

COURSE INFORMATION SHEET

Course code: BE 303
Course title: Mass Transfer Operations
Pre-requisite(s): Chemical Process Calculations (BE 206); Fluid Mechanics & Heat Transfer (BE 209)
Co- requisite(s): Bio separation Engineering (BE 307); Reaction Engineering (BE 304)
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: Fifth/ Third
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

A.	Understand the basic principles in mass transfer operations
B.	Decide among different extraction method for industrial operation
C.	Separate a component from a mixture
D.	Apply their knowledge to purify a bio molecule after production

Course Outcomes

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

1.	Explain the basic principles involve in mass transfer operations
2.	Design a distillation column
3.	Separate bio molecules using solvent extraction method
4.	Extract soluble particle from solid using leaching method
5.	Isolate a bio-molecule by advance separation methods

Syllabus **3 Credits**

Module-I: Diffusion

Molecular diffusion in fluids; Theory of diffusion: Fick's law, analogy between heat, mass and momentum transfer; Diffusivity; Mass Transfer Coefficients; mass transfer in biological system. Vapour liquid equilibrium; Phase diagram; Roult's Law for ideal solution; relative volatility. [8]

Module-II: Distillation

Introduction to distillation, different types: azeotropic, differential, vacuum, steam, flash distillation. Distillation column: mass balance equations, McCabe-Theile Method to calculate number of ideal plate, 'q' line, feed plate location; reflux ratio, maximum, minimum and optimum reflux; minimum number of plates; plate efficiency. [7]

Module-III: Liquid-liquid extraction

Introduction to extraction; Ternary liquid equilibria: triangular graphical representation and binodal curve; single stage batch extraction; multistage continuous operation; determination of number of stages; aqueous two phase extraction. [7]

Module-IV: Solid-liquid extraction

Leaching, solid-liquid equilibria; factors influencing leaching; equipments used in solid-liquid extraction; single stage leaching; continuous multistage leaching; graphical determination of number of stages. [6]

Module-V: Advanced Separation Processes

Supercritical fluid extraction and reverse micelle extraction, Reactive extraction and distillation with case study. [7]

Text books:

1. Warren McCabe, Julian Smith, Peter Harriott, Unit Operation of Chemical Engineering, 7th Ed., McGraw Hill Education, 2017
2. Robert Treybal, Mass Transfer Operations, 3rd Ed., McGraw Hill Education, 2017

Reference books:

1. Leonard A. Wenzel, Curtis W. Clump, Louis Maus, L. Bryce Andersen Alan S. Foust, Principles of Unit Operations, 2nd Ed., Wiley, 2008
2. B.K. Dutta, Principles of Mass Transfer and Separation Processes, 1st Ed., Prentice Hall India Learning Private Limited, 2006

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

NIL

POs met through Gaps in the Syllabus

NIL

Topics beyond syllabus/Advanced topics/Design

NIL

POs met through Topics beyond syllabus/Advanced topics/Design

NIL

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	√
Tutorials/Assignments	√
Seminars	√
Mini projects/Projects	√
Laboratory experiments/teaching aids	√
Industrial/guest lectures	√
Industrial visits/in-plant training	√
Self- learning such as use of NPTEL materials and internets	√
Simulation	√

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	10	15			
Faculty Assessment				**2.5**	**2.5**
End Sem Examination Marks	8	12	10	10	10
Assignment / Quiz (s) (2 No.)	**4**	6	4	3	3

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	2				2	2	2	2	3	2	1
2	3		3	3		3	2	2	2	3	2	1
3	3	3			3	3	2	2	2	3	2	1
4	3	3	3		3	3	2	2	2	3	3	1
5	3	3	3	3		3	2	2	2	3	3	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1, 2, 3,4,5	CD1
CD2	Tutorials/Assignments		CO3, 4	CD1
CD3	Seminars		CO5	CD1 & CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE304
Course title: Reaction Engineering
Pre-requisite(s): Knowledge about Mathematics and Chemistry
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P:
Class schedule per week: 03
Class: B. Tech
Semester / Level: V/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	Introduce basic concepts of chemical kinetics like homogeneous and heterogeneous reactions, rate of reaction, order and molecularity of reaction, concentration and temperature dependency of rate of reaction
B.	Knowledge on different types of chemical reactors
C.	Design of chemical reactors under isothermal conditions
D.	Kinetics of heterogeneous reactions

Course Outcomes

After the completion of this course, students will be:

1.	Apply the principles of reaction kinetics, formulate rate equations and analyse the batch reactor data.
2.	Analyze the experimental kinetic data to select a suitable reactor for a particular application and to workout conversion and space time for different types of reactors.
3.	Evaluate selectivity, reactivity and yield for parallel and mixed reactions.
4.	Examine how far real reactors deviate from the ideal.
5	Kinetics of heterogeneous reactions

Reaction Engineering 3 Credits

Module-1: [8]

Kinetics of Homogeneous Reactions: classification of reactions, reaction rate, speed of reaction, rate equation, concentration-dependent term of rate equation, rate constant, order and molecularity, representation of elementary and nonelementary reactions, kinetic models for nonelementary reactions, temperature-dependent term of a rate equation, activation energy and temperature dependency.

Module-2: [8]

Kinetic Analysis of Batch Reactor Data: Integral and differential methods for analyzing kinetic data, interpretation of constant volume batch reactor, data for zero, first, second and third order reactions, half-life period, irreversible reaction in parallel and series, auto catalytic reaction.

Module-3: [8]

Kinetic Interpretation of Batch Reactor Data for Single Reactions: interpretation of variable volume batch reaction data for zero, first and second order reactions, Ideal batch reactor, steady state CSTR and plug flow reactors and their use for kinetic interpretation.

Module-4: [8]

Design for Single Reaction: Size comparison of single reactors, plug flow reaction in series and/or parallel, equal and different size of mixed reactor in series, finding the best system for given conversion, recycle reactor, Energy balance equations for batch, CSTR and PFR and their application to the design of reactors; Non ideality; Residence time distribution.

Module-5: [8]

Reaction Catalyzed by Solids: Introduction to heterogeneous reactions, rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics, porous catalyst particles, performance equations for reactors containing porous catalyst particles, experimental methods for finding rates; references to bio catalysis, immobilized enzymes.

Text Books

1. Levenspiel, O. Chemical Reaction Engineering Ed.3, John Wiley & Sons (Asia)

Reference

1. K.A. Gavhane, Chemical Reaction Engineering I, Ed 7, 2006, Nirali Prakashan
2. H.ScottFoggler, Elements of Chemical Reaction Engineering, Ed 5, 2016, Prentice Hall
3. Paulin Doran, Bioprocess Engineering Principles. Ed 2, 2013, Elsevier

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
End Sem Examination Marks	60
Assignment / Quiz (s)	15

Assessment Compoents	CO1	CO2	CO3	CO4	C05
Mid Sem Examination Marks	**3**	**2**			
End Sem Examination Marks	**3**	**3**	**3**	**3**	**3**
Assignment			**2**	**2**	

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	3	3	2						
2		3	3	3	3							
3		3	3					1	2			
4		**3**	3	3	3	2					2	

5	x	x	x	x	x			x				

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1,2,3,4	CD1
CD2	Tutorials/Assignments		CO2,3	CD1 and CD8
CD3	Seminars		CO2	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: **BE305**
Course title: Molecular Biology and rDNA Technology lab
Pre-requisite(s): NIL
Co- requisite(s): Nil
Credits: 1.5 L:0 T:0 P:3
Class schedule per week: 03
Class: B. Tech
Semester / Level: Vth /3rd
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

A.	This is a research based course in which student will learn to apply molecular biology techniques (focused on nucleic acids) in the laboratory to ask scientific questions.
B.	Students will learn principles and practice of basic bacterial culture techniques, transformation, agarose gel electrophoresis, nucleic acid purification (plasmid and genomic DNA, RNA), nucleic acid quantification.
C.	DNA restriction digestion and analysis, Southern hybridization, library construction, polymerase chain reaction (PCR), and basics of computer-based DNA sequence analysis and data acquisition over the internet.
D.	In addition, students will learn about the nature and selection of DNA cloning vectors, restriction enzymes, modifying enzymes, polymerases, and other reagents used in molecular biology.
E.	Students will examine aspects of bioinformatics and genomics, and newer/advanced molecular technologies such as next-generation sequencing. Student will apply newly learned molecular techniques toward solving real biological research questions.

Course Outcomes

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

1.	List and explain safety issues and proper practices associated with standard molecular techniques, including bacterial culture, electrophoresis, and nucleic acid purification and detection chemistry.
2.	Demonstrate and practice principles of bacterial culture, sterile technique, transformation, and DNA and RNA purification and quantification.
3.	Understand the nature of molecular biological hypothesis and testing, how molecular analysis answers scientific questions.
4.	Use the application of various standard bioinformatic techniques to experimental

	planning and analysis, including sequence accessing and manipulation, BLAST, multiple sequence alignment, PCR primer design, etc.
5.	Understand the many variations on PCR and when to use them, and how to troubleshoot a PCR protocol by selecting parameters.
6.	Independently plan, execute and document a basic DNA cloning experiment involving PCR amplification.

BE305 Molecular Biology and rDNA Technology lab

Credit:3

Sl. No.	Name of the Experiments
1.	Isolation of DNA from Bacteria and plant tissue
2.	Isolation of Plasmid DNA from Bacteria
3.	Agarose gel electrophoresis of isolated DNA
4.	Use of BLAST and other bioinformatics tools like MSA
5.	Primer designing for PCR experiment
6.	PCR of the selected DNA template
7.	Cloning of the amplified product in suitable host cell using plasmid vector

Books Recommended:

1. Laboratory Manual for Analytical Biochemistry and Separation techniques (2000) by P. Palanivelu, Madural Kamaraj University.
2. Sambrrok, J. and Russell, D.W. (2003). Molecular Cloning-A laboratory Manual (3 rd Edition, Vol.1, 2 and 3), Cold Spring Harbor Laboratory Press, Cold Spring Harbor, New York.9.David Mount (2001)
3. Bioinformatics. Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press.10.Rashidi, H.H. and Buehler, L.K. (2002).
4. Bioinformatics Basis: Applications in Biological Science and Medicine. CRC Press, London.11.Primrose et al. (2005) Principles of gene manipulation, Black Well Science, London.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	√
Tutorials/Assignments	√
Seminars	√
Mini projects/Projects	
Laboratory experiments/teaching aids	√
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3		3									
2	3	3	3	3	3							
3	3	3	3		3	2			2			1
4	3					2			2	2		
5		3	3			2		2				
6				3			2			2		1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids		CO1, CO2, CO3, CO4, CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		CO5	
CD7	Industrial visits/in-plant training		CO4, CO5	
CD8	Self- learning such as use of NPTEL materials and internets		CO1 and CO2	
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE306
Course title: **BIOANALYTICAL TECHNIQUES LAB**
Pre-requisite(s): BE301
Co- requisite(s): NIL
Credits: 1.5 L: T: P: 3
Class schedule per week: 12 per week for 1.5 months
Class: B.Tech.
Semester / Level: V Sem
Branch: Bio-Engineering
Name of Teacher:

Credit: 1.5

BE306 BIOANALYTICAL TECHNIQUES LAB

Experiment 1:	Demonstration and Experiment on Gas Chromatography
Experiment 2:	Demonstration and Experiment on Liquid Chromatography
Experiment 3:	Mass analysis of molecules using Mass Spectrometry
Experiment 4:	Measurements of absorbance and transmittance using UV/VIS spectrophotometry
Experiment 5:	Material characterization using DSC
Experiment 6:	Material characterization using TGA
Experiment 7:	Material separation using ultracentrifuge (AUC)
Experiment 8:	Demonstration and Experiment on GEL Electrophoresis
Experiment 9:	Demonstration and Experiment on SEM
Experiment 10:	Analysis of AES/AAS using ICP-OES

Books

1. **K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.**
2. **Willard and Merrit, Instrumental Methods and Analysis**
3. **Ewing GW, Instrumental Methods of Chemical analysis.**

Course Outcomes

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

1.	Apply knowledge of mathematics, science, and engineering to understand molecular phenomena.
2.	An ability to design and conduct experiments, as well as to analyze and interpret data for related to domain of Bioinstrumentation. Evaluate the limitations of and troubleshoot theoretical approaches.
3.	Design a system, component, or process to performing research in biological system and addressing the challenges associated with the Centrifugation Techniques and Electro-

	kinetics. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4.	Use the techniques, skills, and modern tools necessary for detection of the validation of new biomolecules and its interaction and analysis of data, and interpretation of results.
5.	Demonstrate knowledge and understanding of the engineering principles and knowledge of various types of industrially used Chromatographic Techniques and imaging methods; advantages and disadvantages, design criteria, molecular imaging, instrumentation and various aspects of operation.
6.	Validation, compatibility and an ability to understand, design and application of the processes of Spectroscopy and Thermal Analysis
7.	Independently execute an experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained. An ability to prepare a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in governmental and private agencies in multidisciplinary teams. An ability to identify, formulate, and solve engineering problems.

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows) a) Day to day performance & Lab files b) Quiz (es) c) Viva	60 30 10 20
Semester End Examination (Distribution is as follows) a) Examination Experiment Performance b) Quiz	40 30 10
Total	100

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3		3	3	2	2		2	2		
2		3	3		3		2	2	2	2		
3	3	3		3	3			2	2	1		
4		3		3	3	2				2		1
5	3	3		3			2	2		1	2	1
6		3		3	3	2		2	2	1		
7		3	3	3				2		1	2	1

COURSE INFORMATION SHEET

Course code: BE 307
Course title: Bioprocess Engineering
Pre-requisite(s): BE101 Biological Science for Engineers, BE303 Mass Transfer Operations
Co- requisite(s):
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: V
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	to understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess
B.	about media constituents, formulations and sterilization, types of sterilizes and role of filers on sterilization
C.	Provide knowledge of kinetics of enzymes both in free and in immobilized state
D.	Gain knowledge about the mode of reactor operation and significance of CFD in bioprocessing

Course Outcomes

After the completion of this course, students will be:

1.	Able to explain the kinetics of cell biomass accumulation and product formation, analysis of data and interpretation
2.	Competent to identify and design sterilizers for removal of microbial contaminants
3.	Learn the biocatalysis and significance of immobilization
4.	Able to operate bioreactor as per microbial need and able to work in multidisciplinary team
5	Capable of identifying the crucial pathways in bioprocess regulation

Syllabus **Credit: 3**

Module-1:
Cell Growth and Product Formation: Cell growth and bio-product formation kinetics, Quantification of cell growth, growth patterns and kinetics in batch culture, environmental factors affecting growth kinetics, heat generation by microbial growth, unstructured non segregated model, models for transient behaviour. [7]

Module-2:
Mass Balance and Yield Concepts: Yield and maintenance coefficients, calculation based on elemental balances, degree of reduction, theoretical predictions of yield coefficients. [7]

Module-3:
Sterilization: Media and air sterilization, Sterilization equipment, Kinetics of death, Batch and continuous sterilization of media, Role of membrane filters for sterilization of media and air. [7]

Module-4:
Enzyme Immobilization: Kinetics of free and immobilized enzymes, Immobilized enzyme reactors and Diffusion limitations. [7]

Module-5:
Operating considerations for bioreactors: Batch, fed-batch and continuous bioreactors, ideal plug flow tubular reactors, Concepts of computational fluid dynamics in bio-processing. [7]

Text 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

Reference Books:
1. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.
2. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors-	Yes
Tutorials/Assignments-	Yes
Seminars	
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation-	Yes

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure
Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		
Faculty Assessment		√			
End Sem Examination Marks	√	√	√	√	√
Assignment		√	√		

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcomes	Program Outcomes											
	a	b	c	d	e	f	G	h	i	J	k	l
1	3	3	3		3							1
2	3		3		3	2	2		2			1
3		3	3	3			2	2	2		2	1
4					3	2		2		2	2	1
5	3		3	3	3	2			2		2	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1,2,3,4,5	CD1
CD2	Tutorials/Assignments		CO2, 3	CD1, CD8
CD3	Seminars		CO4, 5	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE 308

Course title: Bioseparation Engineering

Pre-requisite(s):

Co- requisite(s): BE307 Bioprocess Engineering

Credits: 3 L:3 T: P:

Class schedule per week: 03

Class: B. Tech

Semester / Level: VI/3

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students:

A.	To understand outline of recovery processes, removal of biomass including solids matters by filtration, centrifugation and sedimentation etc and learn the techniques of cell disruption, their limitations and applications
B.	To gain knowledge regarding principles, methods and applications of different methods for extraction of desired product from the clarified fermentation broth
C.	About the concept of various chromatographic techniques for separation and identification of targeted compound
D.	Provide the information of finishing operations and quality control related issues for the purified product

Course Outcomes

After the completion of this course, students will be:

1.	Able to develop the ability to design and conduct experiments related to separation of targeted products, as well as analyze and interpret data
2.	Able to work in multidisciplinary teams
3.	Learn various techniques, skills, and modern engineering tools necessary for bioseparation engineering practice
4.	Competent enough to propose the separation process for extraction of bio-products from biological systems

Bioseparation Engineering **Credit: 3**

Module -1:
Principle of Separation Based on Size and Shape:
Pre-treatment, Sedimentation, Filtration, Centrifugation, Coagulation and flocculation, Disruption of living cells to release the intracellular products: Mechanical and Non-mechanical methods with their limitations and applications. [8]

Module -2:
Separation of Soluble Products: Adsorption, Adsorption isotherm. Liquid-liquid extraction, Aqueous two phase extraction and Precipitation. [8]

Module -3:
Membrane Based Separation: Dialysis, Reverse osmosis, Ultrafiltration and microfiltration, Cross-flow ultrafiltration and Electro-dialysis. [8]

Module -4:
Chromatography: Adsorption chromatography, Gel-filtration, Ion-exchange Chromatography, Affinity Chromatography, High Pressure Liquid Chromatography and Hydrophobic Chromatography. [8]

Module -5:
Finishing Operations: Crystallization, drying of product and packaging. [8]

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

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: nil

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors-	Yes
Tutorials/Assignments-	Yes
Seminars	
Mini projects/Projects	
Laboratory experiments/teaching aids-	Yes
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	√	√		
End Sem Examination Marks	√	√	√	√
Assignment		√	√	

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcomes	Program Outcomes											
	A	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3				2					1
2	3	3			3			1	2	2		1
3	3	3	3	3	3	2	2	2	2	2	2	1
4	3	3		3	3	2	2			2	1	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO 1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments		CO 2, 3	CD1, CD8
CD3	Seminars		CO 3, 4, 5	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE 309
Course title: Fermentation Engineering
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VI/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	The course introduces the basic principles of Fermentation Technology which involves various strategies for strain selection and improvement, media formulation, sterilization, inoculums development, various fermenter configurations and mode of operations.
B.	Agitation and mixing characteristics in fermentation
C.	Knowledge about heat transfer in fermenters
D.	Fermentation process and equipment design concepts

Course Outcomes

After the completion of this course, students will be:

1.	To apply chemical engineering principles to fermentation processes
2.	The inocula development and improvement of cultures and the evaluation of fermentation processes.
3.	The fermenter configuration and mode of operations
4.	Heat transfer in Fermenters
5	The industrial applications of fermentation technology

Syllabus **3 Credits**

Fermentation Engineering

Module 1: [8]

Introduction: Introduction to Industrial Fermentation process; Historical overview of industrial fermentation products; Biochemistry of Fermentation – Bacterial, Fungal and Yeast Fermentation; Comparison between traditional and modern methods of fermentation; Industrially useful microorganisms and its products.

Module 2: [8]

Integration of Bio Reactors on Industrial Fermentation Processes: Classification of fermentors; fermentor operation (batch, fed-batch, continuous); Conventional and non-conventional fermenters; equipment characteristics

Module 3: [8]

Fluid Flow, Mass Transfer, Agitation and Mixing in Fermenters: Agitation and mixing characteristics in fermentation, Power requirement, Influence of power input on oxygen transfer. Rheology: Viscosity and shear stress. Newtonian and non-Newtonian fluids. Rheology of fermentation broths. Flow patterns in stirred tanks. Quantification of mixing phenomena in stirred vessels; Oxygen transfer in fermentation; Relationship between OTR, volumetric mass transfer coefficient and hydrodynamic parameters in bioreactors at several levels with consideration to rheology

Module 4: [8]

Heat Transfer in Fermenters: Heat transfer characteristics in fermentation; Types of heat exchangers; heat exchangers in large scale fermentation production; internal cooling; jacket cooling; film cooling; refrigerants used for fermentation cooling; heat exchangers design concepts

Module 5: [8]

Fermentation Process and Equipment Design Concepts: Pharmaceutical fermentation equipment; Case studies – Fermentation for pharmaceutical products; Simulation of pharmaceutical manufacturing processes using software

Text Book:

1. Bioprocess Engineering Principles 2nd Edition, by Paulin Doran, eBook ISBN: 9780080917702; Paperback ISBN: 9780122208515; Academic Press 2012

References:

1. Fundamental Bioengineering Volume 1 Ed : John Villadsen; Advanced Biotechnology Series; Series Editors: S. Y. Lee, J. Nielsen, G. Stephanopoulos; Print ISBN: 978-3-527-33674-6 ; ePDF ISBN: 978-3-527-69746-5; Wiley - VCH 2016
2. Fermentation and Biochemical Engineering Handbook (Third Edition) *Edited by:Celeste C. Todaro and Henry C. Vogel* ISBN: 978-1-4557-2553-3; Elsevier 2014.

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	C05
Assignment			√	√	
Faculty Assessment	√				
Mid Sem Examination Marks	√	√			
End Sem Examination Marks	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l

1	3	3	3	3	3	3						
2	3	3	3	3	3							
3	3	3	3					2	2	2		
4	3	3	3	3	3					2	2	1
5	3		3	3	3	3		2	2	2	2	1

If satisfying< 34%=1, 34-66% =2, > 66% = 3.

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1,2,3,4,5	CD1
CD2	Tutorials/Assignments		CO2,3	CD1 and CD8
CD3	Seminars		CO2	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation		CO5	

COURSE INFORMATION SHEET

Course code: BE310
Course title: Bioprocess Enginnering Lab
Pre-requisite(s):
Co- requisite(s): Nil
Credits: 1.5 L: 0 T: 0 P: 3
Class schedule per week: 2
Class: B. Tech
Semester / Level: VI/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

A.	establish an understanding of the growth characteristics of microorganism in liquid culturing conditions.
B.	To familiarize students with different methods parts of fermeter and fermentation process.
C.	give them knowledge about preparation of standard plots for estimation of desired product and residual components.
D.	expose students for analysis of mass balance related with kinetics of enzyme/ cells at laboratory as well as industrial level.

Course Outcomes

After the completion of this course, students will be:

1.	Able to understand the role of media and constituents for growth and their effect
2.	Able to know about different phases of growth in batch mode cultivation
3.	Capable of knowing the role of calibration process like pH, DO etc in fermentation systems
4.	They will be able to analyze the mass balance after completion of process
5.	They will be able to design the steps of kinetic study of enzymes both at free state and immobilized state at laboratory and industrial scale

Syllabus for laboratory experimentation:

S. No:	**Name of Experiments**
Experiment 1:	Study of different culture systems and media
Experiment 2:	Shake Flask Culture
Experiment 3:	Bioreactor parts and accessories
Experiment 4:	Calibration of pH electrode and DO probe

Experiment 5:	To prepare standard plot of protein
Experiment 6:	To prepare standard plot of ammonia
Experiment 7:	To prepare standard plot of sugar
Experiment 8:	Growth of microorganisms and mass balance
Experiment 9:	Immobilization of enzymes by entrapment
Experiment 10:	Kinetic study of enzymes

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓
Seminars	
Mini projects/Projects	
Laboratory experiments/teaching aids	✓
Industrial/guest lectures	
Industrial visits/in-plant training	✓
Self- learning such as use of NPTEL materials and internets	
Simulation	✓

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Continuous Internal Assessment 60% (Distribution is as follows)	**60**
a) Day to day performance & Lab files	**30**
b) Quiz (es)	
c) Viva	**10**
	20

Semester End Examination (Distribution is as follows) **a) Examination Experiment Performance** **b) Quiz**	**40** **30** **10**
Total	**100**

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes**											
	a	b	c	d	e	f	g	h	i	j	k	l
1	**3**	**3**				**3**						
2	**3**	**3**		**3**		**3**	2					1
3	**3**	**3**	**3**		2	**3**		2				1
4	**3**	**3**	**3**	**3**		**3**			2			
5	**3**	**3**	**3**	**3**		**3**	2	2	2		2	1

COURSE INFORMATION SHEET

Course code: **BE 311**
Course title: **Mass Transfer and Bioseparation Engg. Lab**
Pre-requisite(s): **BE303**
Co- requisite(s): **NIL**
Credits: 1.5 **L: 0 T: 0 P: 3**
Class schedule per week: 03
Class: **B. Tech**
Semester / Level: **Six**
Branch: **Biotechnology**
Name of Teacher:

This course enables the students:

1.	To acquire a sound knowledge on mass transfer operations
2.	To understand bio-separation processes
3.	Heat and mass transfer equipments
4.	To learn solid-liquid mass transfer

Course Outcomes

After the completion of this course, students will be:

CO1	Analyze the fundamental properties mass transfer and bio-separation
CO2	Perform liquid-liquid separation by distillation
CO3	Separate proteins by adsorption, precipitation, and extraction
CO4	Execute the operations of extraction and drying

BE311 Mass Transfer and Bioseparation Engineering Lab

Credit: 1.5

S. No:	Name of Experiments	CO	PO
Experiment -1	To study operation of sieve shaker.	1	a, b. c, l
Experiment -2	Studies on performance of ball mill.	1,2	c, d, e, l
Experiment -3	To study different parameters on solid-liquid extraction.	2,3	a, c, e, l
Experiment -4	To plot drying curve under fluidized bed condition.	3,4	f, i, k, l
Experiment -5	To determine drying rate of rotary dryer.	1,2,3	a, e, g, l
Experiment -6	To perform the operation of plate and frame filter press and evaluation of specific cake and medium resistance.	1,4	c, f, h, k, l
Experiment -7	To study operation of rotavapour.	3,4	c, h, m, l
Experiment -8	To study the performance of rotary drum filter.	2,3	b, e, j, l
Experiment -9	To study the precipitation process.	1,2,3	a, d, g, i, l
Experiment -10	To perform binary distillation in a bubble cap column	1,2	b, e, j, l
Experiment -11	To perform batch rectification in a packed distillation column	1,2	c, d, e, l

Experiment -12	To perform Adsorption with chemical reaction in a packed bed	2,3	a, c, e, l
Experiment -13	To perform Vapour in air diffusion	3,4	f, i, k, l
Experiment -14	To perform Mass transfer with or without chemical reaction	1,2,3	a, e, g, l
Experiment -15	To perform Heat transfer in agitated jacketed vessel	1,4	c, f, h, k, l
Experiment -16	To study of drop wise and film wise conduction	3,4	c, h, m, l
Experiment -17	To Study packed bed reactor	2,3	b, e, j, l
Experiment -18	To perform plate and frame type heat exchanger	1,2,3	a, d, g, i, l
Experiment -19	To perform fluidized bed reactor	1,2	c, d, e, l

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows) a) Day to day performance & Lab files b) Quiz (es) c) Viva	 60 30 10 20
Semester End Examination (Distribution is as follows) a) Examination Experiment Performance b) Quiz	40 30 10
Total	100

Assessment Components	CO1	CO2	CO3	CO4
Progressive evaluation Marks	3	3	2	2
End SEM Examination Marks	3	3	3	3
Quiz (s)	3	3	3	2

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

Indirect Assessment

5 Student Feedback on Faculty

5 Student Feedback on Course Outcome

COURSE INFORMATION SHEET

Course code: BE312
Course title: Biomaterials
Pre-requisite(s): BE204 Biochemistry and Enzyme Technology
Co- requisite(s):
Credits: L: 03 T:00 P:00
Class schedule per week: 03
Class: B. Tech
Semester / Level: V/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To gain knowledge about the fundamental concepts in biomaterial science, their specific properties
B.	Understand material selection, classes of biomaterials used in medicine and structure-function relationship
C.	Explain basic principles of biocompatibility and implant performance List different strategies to modify and/or design materials that are biocompatible
D.	Explain what biodegradability is and how it affects biomaterial design
E	To get familiarized with biomaterials used in different medical applications and their testing techniques

Course Outcomes

After the completion of this course, students will be:

1.	Able to understand the fundamental concepts, properties and handling of biomaterial
2.	Understand major classes of materials used in medicine: metals, ceramics and polymers with specific medical requirement
3.	Understand mechanism of biological response to implanted biomaterials and ability to improvise strategies for designing biocompatible biomaterials
4.	Understand biodegradation of biomaterials: intentional and un-intentional degradation mechanisms and ability to improvise strategies for designing biodegradable biomaterials
5	Knowledge of techniques to modify biomaterial surfaces to control the biological response and instrumentations to examine surface chemistry
6	Ability to apply fundamental principles for designing and testing biomaterials for specific medical application. Familiarize themselves with biomaterials potentialities and be able to apprehend and explain use of biomaterials in different medical applications.

Syllabus

Module-1: **[8]**

Fundamentals of Biomaterials Science: Functional requirements of biomaterials and tissue replacement, Salient properties of important material classes, Property requirement of biomaterials, Disinfection and sterilization of biomaterials.

Module-2: **[8]**

Materials Used in Medicine: metals, polymers, ceramics, gels, hybrids, basic properties, medical requirements and clinical significance.

Module-3: **[8]**

Biological Response to Biomaterials: biocompatibility and hemocompatibility, foreign body response to implanted biomaterials, Immune response to foreign materials.

Module-4: **[8]**

Bioresorbable and Biodegradable Biomaterials: ceramics and their clinical significance, Biodegradables polymers, biodegradation of biomaterials, techniques to modify biomaterial surfaces to control the biological response and instrumentations to examine surface chemistry.

Module-5: **[8]**

Biomaterial Applications: biomaterials used in different medical applications (e.g., soft and hard tissue replacements, cardiovascular, drug delivery, biosensors, and tissue engineering). In-vitro cytocompatibility testing of biomaterials.

Text Books Recommended:

1. *Biomaterials Science, An Intoduction to Materials in medicine*, eds. Ratner, B.D. et al. 2nd Ed. 2004

2. Biomaterials: The Intersection of Biology and Materials Science by J.S. Temenoff and A.G. Mikos, Pearson Prentice Hall, 2008.

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

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design: NA

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	√
Tutorials/Assignments	√
Seminars	√
Mini projects/Projects	√
Laboratory experiments/teaching aids	
Industrial/guest lectures	√

Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	**10**	**10**	**5**			
Faculty Assessment	**1**	**2**	**2**			
End Sem Examination Marks		**10**	**10**	**10**	**10**	**10**
Assignment	**5**	**5**	**5**	**5**		

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3											
2	3	3										
3	3		3	3	3							
4	3		3	3	3							
5	3				3	2						
6				3	3		2		2			1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE313
Course title: Metabolic Engineering
Pre-requisite(s): BE202 Cell and Molecular Biology, BE204 Biochemistry and Enzyme Technology
Co- requisite(s):
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level:VI/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	Students will understand about cellular metabolism, their coordination and regulation
B.	Will get knowledge about metabolic kinetics, mass balances and metabolic regulation identifications
C.	To impart knowledge about the programming and cell capability and metabolic flux analysis
D.	To establish an understanding about metabolic control and pathways analysis, modelling and various application

Course Outcomes

After the completion of this course, students will be:

1.	able to understand about detailed cellular metabolism, coordination and their regulation
2.	Know about kinetics and mass balances for transient cases as well as flux analysis
3.	Able to understand about various pathways involved in metabolic control analysis
4.	Able to design different models and algorithm as well as understand about detailed application

Syllabus

Module-1: [8]
Cellular Metabolism: Overview of cellular metabolism, Fueling Metabolism, Supply of biomass precursors, Coordination of metabolic reactions, Metabolic strategies and regulation.

Module-2: [8]
Metabolic Networks: Kinetics, mass balances for the steady state, mass balances for the transient case, Metabolic regulation identification.

Module-3: [8]
Metabolic Flux Analysis: Linear programming, Cell capability analysis, Genome scale, Isotope labeling, Metabolic flux analysis and its applications,

Module-4: [8]
Metabolic Control Analysis: Determination of flux control coefficient, Metabolic control analysis in linear and branched pathways, Analysis of metabolic control and the structure

Module-5: [8]
Metabolic Network Design and Application: Metabolic pathway modeling, Metabolic pathway synthesis algorithms, Application in pharmaceuticals, Chemical bioprocess, Food technology, Environmental bioremediation.

Text

1. Metabolic Engineering: Principles and Methodologies. Edited by G. Stephanopoulos, A.A. Aristidou, J. S. 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.

***References*:**

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. Modeling Metabolism with Mathematica. P. J. Mulquiney and P. W. Kuchel, CRC Press, 2003.
4. Pathway Analysis and Optimization in Metabolic Engineering. N. V. Torres and E. O. Voit, Cambridge University Press, 2002.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**
Mid Sem Examination Marks	√	√		
End Sem Examination Marks	√	√	√	√
Assignment */Quiz *	√	√	√	√

* two quizzes: Quiz 1- CO1 & CO2; Quiz 2-CO3 & CO4

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcomes	**Program Outcomes**											
	A	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3		3		2				2	1
2	3	3			3			2		2	2	1
3	3		3			2		2	2	2	2	1
4	3			3		2	2			2	2	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1, 2, 3, 4	CD1
CD2	Tutorials/Assignments/Quiz		CO1, 2, 4, 4	CD1 and CD8
CD3	Seminars		CO1, 2, 3, 4	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE314
Course title: Biosignal Acquisition and Analysis
Pre-requisite(s):EC101 Basic Electrical and Communication Engineering
Co- requisite(s):BE215 Cellular Electrophysiology
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level:VI/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge on biomedical signal acquisition.
B.	To learn the technicality associated with instrumentation and design of basic biosignal equipment.
C.	To record and analyse the engineering aspects for safety and hazards associated with biosignal recording.
D.	To record and interpret the characteristics of different biosignals.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the components of man-machine interaction.
2.	Understand the fundamentals of the concept and design of biosignal recorder.
3.	Identify the electrical hazards associated with biosignal recording so that the safety equipment can be devised or suggested.
4.	Analyse the characteristics and features of biosignals under different events.
5.	Work in an interdisciplinary team.

Syllabus

Biosignal Acquisition and Analysis

Module-1: **Concept and Factors in Data Acquisition**: Category and factors in measurement, biometrics, problems encountered in measuring a living system, Electrical safety considerations, Types of bio-signal and its sources. [8]

Module-2: ***Sensors and Transducers***: Electrodes for bio-physiological sensing, Transducers and sensors in biological applications, Recording problems and its remedy. [8]

Module-3: ***Bioelectric amplifiers and filters***: Different types of amplifiers and their principles of operation, Types of filters and their applications. [8]

Module-4: Recording and digitization of signals: Types of recorder, analog and digital filters, Concept of analog to digital conversion. [8]

Module-5: ***Biosignal Analysis***: Interpretation of electrocardiogram, electromyogram and electroencephalogram; Special techniques in analysis of biosignals. [8]

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: a, b, c, f

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

POs met are: f, g

Course Delivery methods

Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i	3			2								
ii		3	3	3	2	2						
iii	3				3	2		3	2		2	
iv				3	3				2	2		2
v									3	2	3	

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO4	CD5

COURSE INFORMATION SHEET

Course code: BE315
Course title: Food Science and Technology
Pre-requisite(s): BE204 Biochemistry and Enzyme Technology
Co- requisite(s):
Credits: 3 L:3 T:0 P:0
Class schedule per week: 3
Class: B. Tech
Semester / Level: V/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To develop an understanding of food composition, concept of balanced diet
B.	To describe microbial interactions and their significance in food principles of preservation,
C.	To outline principles of food processing and preservation methods used in the control of microorganisms and apply this understanding for the prevention /control of food spoilage
D.	To establish information related to food quality, analysis and food safety laws
E.	To think critically regarding a topic and deliver scientific principles to both scientists and non-scientists related to food industry

Course Outcomes

After the completion of this course, students will be:

1.	Identify the importance of different types of food in balanced diet and diet planning
2.	Assess the beneficial or detrimental ways in which microorganisms have an impact on food
3.	Evaluate the different techniques used in food processing and preservation
4.	Determine food quality by food analysis as per food safety laws and standards.
5.	Compare and contrast foods types available in the market and design new product development strategies
6.	Apply the scientific method by stating a question; researching the topic; collecting, analyzing, and presenting data and communicate with both specialist and non-specialist audiences using genres commonly used in food industry

Syllabus
Food Science & Technology

Credit:3

Module-1: [8]

Food groups and their classification. Concept of balanced diet, malnutrition, recommended dietary allowances (RDAs) for various age groups according to their physiological status for specific nutrients and energy. Diet Planning; Macronutrients, micronutrients, enzymes and pigments in food, their role and importance in processing and food consumption. Food Rheology, Application of rheology in food system.

Module-2: [8]

Food Microbiology: Fermented foods, Microbial growth in food (important factors). Food spoilage by micro-organisms**,** Food-borne illness**,** Classification of foods on the basis of spoilage.

Module-3: [8]

Food Processing and Preservation: Traditional processing methods: different cooking, smoking, baking, frying methods and types with advantages and disadvantages. Principles of preservation in correlation to increase the shelf life of food, Protein engineering in food technology: Objectives, methods, limitations and applications

Module-4: [8]

Food Safety Laws and Standards: Food quality & analysis: Pre and Post-harvest factors in food quality, Physical, Chemical and Microbiological factors of quality, proximate analysis of foods, Sample and sample preparation in foods. Food laws: Voluntary and Mandatory food laws in India. Food Certification Agencies.

Module-5: [8]

Impetus in Food Industry: New Product Development, strategies, planning for marketing, Process designing of food. Different metals used in cooking of food from traditional to plastic and storage of food with advantages and disadvantages. Foods types available in the market need of their innovation, advantages and disadvantages

Text books:

1. G.F. Stewart, Introduction to Food Science and Technology, 2nd Ed., Academic Press, 2012
2. Frazier William C and Westhoff, Dennis C. Food Microbiology, 5th Ed.,TMH Education, 2017

Reference books:

1. Sunetra Roday, Food Science and Nutrition, 2nd Edition, Oxford, 2012
2. Bhat & Rao, Food safety, The Bangalore Printing And, 1997

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓
Seminars	✓
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	✓
Self- learning such as use of NPTEL materials and internets	✓
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	10	10	5			5
End Sem Examination Marks	5	10	5	10	10	10
Assignment /Quizes-2	5	5	5	5		

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	G	h	i	j	k	l
1	3	3	3				2					
2	3	3		3			2			2		
3	3	3	3			2	2					
4	3	3			3	2		2		2		
5	3	3	3			2		2	2		2	
6		3		3			3	2	2			1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1 and CD8
CD2	Tutorials/Assignments		CO2	CD1, CD3 and CD8
CD3	Seminars		CO3	CD1, CD3, CD7 and CD8
CD4	Mini projects/Projects		CO4	CD1 and CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1 and CD8
CD6	Industrial/guest lectures		CO6	CD1, CD3 and CD8
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: **BE316**
Course title: Bioinformatics Algorithms
Pre-requisite(s): BE205
Co- requisite(s): Nil
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VI
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	An ability to work on basic science as well as biotech/pharmaceutical industry in multidisciplinary teams and independently.
B.	Learn various aspects to design and validate algorithms for bio-sequence analysis and interpreting experimental data from biological system and addressing the challenges associated with the interaction between different biomolecules.
C.	Grab the theoretical knowledge, parameters for searching and designing algorithm Design Paradigms, Motif Finding & Genome Rearrangements for a particular disease related Gene in biological research/ biotechnology/ pharmaceutical in industry and research lab.
D.	Enable students to understand the processes associated with DBMS architecture, Machine learning techniques and Bigdata analysis related to computational Biology.
E.	An UG degree in this field prepares a student for careers in biotech/ pharmaceutical research in different domains including industry.

Course Outcomes

After the completion of this course, students will be:

1.	An ability to apply knowledge and to design, analyse and conduct experiments, related to domain of Bioinformatics.
2.	An ability to validate new Bio-sequences. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
3.	An ability to apply the knowledge to find various parameters for searching and designing metabolic pathway, genomics, proteomics for a particular disease related protein/Gene in biological research/ biotechnology/ pharmaceutical in industry and research lab.
4.	An ability to understand the processes associated with DBMS architecture, Machine learning techniques and Bigdata analysis related to computational Biology.
5.	An ability to design the processes conserved domain search and sequence comparison
6.	A UG degree in this field prepares a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in governmental and private agencies. An

	ability to function in multidisciplinary teams. An ability to identify, formulate, and solve engineering problems.

Syllabus **Credits:3**

Module-1: **[8]**

Database System Versus File Systems: Characteristics of Database, Database Concepts, Schemas & Instances, Database users and Administrators, DBMS architecture. Biological Literature Information access, storage and retrieval systems- Primary and secondary databases of genomics, trascriptomics, proteomics and metabolomics. Knowledge on freeware and commercial software.

Module-2: **[8]**

Introduction, Sorting, Searching, Complexity of algorithms: worst case, average case and amortized complexity, Algorithm Design Paradigms, Big-O and Theta notations.

Module-3: **[8]**

Mapping Algorithms: Motif-Search Trees, Finding Motifs, Finding a Median String. Greedy Algorithm : Motif Finding & Genome Rearrangements, Sorting by Reversals. Approximation Algorithms

Module-4: **[8]**

DNA Sequence comparison: Manhattan Tourist Problem – Edit Distance and Alignments – Longest Commons Subsequences – Global Sequence Alignment – Scoring Alignment – Local Sequence Alignment – Alignment with Gap Penalties – Multiple Alignment-Gene Predictions – Approaches to Gene Prediction - Spiced Alignment – Divide and Conquer Algorithms.

Module 5: **[8]**

Machine learning techniques: ANN and Genetic Algorithm. Applications in Biotechnology

Text books:

1. T.H. Cormen, C.E. Leiserson, and R.L. Rivest, Introduction to Algorithms, The MIT Press, Cambridge, Massachusetts, USA, 1990
2. Neil C. Jones and Pavel A. Pevzner, An Introduction to Bioinformatics Algorithms, MIT Press, First Indian Reprint 2005.
3. Gary Benson Roderic page (Eds), Algorithms in Bioinformatics, Springer International Edition, First Indian Reprint 2004.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	√
Tutorials/Assignments	√
Seminars	√
Mini projects/Projects	
Laboratory experiments/teaching aids	√
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	√
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
Mid Sem Examination Marks	15	10				
End Sem Examination Marks	8	8	10	10	12	12
Assignment + seminar* quizzes (02)	5	5	5	5		5

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	**Program Outcomes**											
	a	b	c	d	e	f	g	h	i	j	k	l
1	**3**		**3**		3		**3**					
2	**3**	3	**3**			2	**3**					

3	**3**		**3**		3			2				
4	3						2		2	2		
5		**3**	**3**			2		2				
6				3			2					1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE317
Course title: Stem Cell and Tissue Engineering
Pre-requisite(s): BE 2016 Pharmaceutical Biotechnology
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI/III
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To give an understanding of the major aspects and basic techniques in stem cells and tissue engineering including applications
B.	To describe basic cell culture technique.
C.	To give the details of design of set for tissue engineering for different cases
D.	Setting up stem cell culture and tissue engineering laboratory

Course Outcomes

After the completion of this course, students will be:

1.	To give an understand the major aspects and basic techniques in stem cells and tissue engineering including applications
2.	They will be able to design the steps of tissue production at laboratory scale.
3.	They will be able to design the laboratory required for tissue production.

Syllabus

Module-1: [8]
Basic Biology of Stem Cells; Types & sources of stem cell with characteristics: embryonic, adult, haematopoietic, fetal, cord blood, placenta, bone marrow, primordial germ cells, cancer stem cells, induced pleuripotent stem cells. isolation & characterizations, markers & their identification.

Module-2: [8]
Stem Cell Culture Requirements: Methods for stem cell culture, Growth factor requirements and their maintenance in culture. Feeder and feeder free cultures. Cell cycle regulators in stem cells.

Module-3: [8]
Applications of Stem Cells: Neurodegenerative diseases, Spinal cord injury, Heart disease,

Diabetes, Burns and skin ulcers, muscular dystrophy, Orthopaedic applications, Eye diseases.

Module-4: [8]

Tissue Engineering: Biomaterials/Biopolymers used in Tissue Engineering, Concepts in scaffold based tissue engineering, tissue engineering approaches to stem cell-based therapies.

Module-5: [8]

Stem Cell Culture and Tissue Engineering Facility: Setting up stem cell culture and tissue engineering laboratory, hazards in stem cell storage & transplantation, Skin and Musculoskeletal applications of tissue engineering.

Recommended Books:

1. R. Lanza, J. Gearhart *et al* (Ed), Essential of Stem Cell Biology, 2009, Elsevier Academic press.
2. Satish Totey, Kaushik D. Deb, Stem Cell Technologies: Basics and Applications
3. J. J. Mao, G. Vunjak-Novakovic *et al* (Eds), Translational Approaches In Tissue Engineering & Regenerative Medicine. (2008), Artech House, INC Publications.

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.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓
Seminars	✓
Mini projects/Projects	✓
Laboratory experiments/teaching aids	✓
Industrial/guest lectures	✓
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	
Simulation	

:

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3
Mid Sem Examination Marks	10	15	
Faculty Assessment		**2.5**	**2.5**
End Sem Examination Marks	20	20	10
Assignment / Quiz (s) (2 No.)	**10**	6	4

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3				2		2				1
2	3	3	3	3	3	3						1
3	3	3	3			2						1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD3, CD4, CD6 and CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD4, CD6 and CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD4, CD6, CD7 and CD8
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			

CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE318
Course title: Bioenergy & Biofuels
Pre-requisite(s): BE 307 Bioprocess Engineering
Co- requisite(s): Nil
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VI/III
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To establish an understanding of the major types of biofuels and energy, biosynthetic pathways, processing and applications.
B.	To give knowledge of Biofuel properties, specifications and guidelines.
C.	To describe production strategies for various Biofuels and to introduce them with technology development for Biofuel production.
D.	To outline principles of biomass conversion of fuels
E.	To describe Environmental assessments due to uses of biofuels-Biofuels economics
F.	To introduce students with biofuels economics

Course Outcomes

After the completion of this course, students will be:

1.	Able to know about different types of biofuels, biosynthetic pathways, processing and applications.
2.	Acquiring knowledge of biofuel properties, specifications and guidelines
3.	They will be able to evaluate the industrially important biofuel and design the technology for the same.
4.	They will be able to analyze the biofuel issues and correlate them with economic aspects.

Syllabus

Module-1: [8]

Introduction to Bioenergy & Biofuels: Introduction to energy – Global energy scene – Indian energy scene – Units of energy, conversion factors, general classification of energy, energy crisis, energy alternatives. Fossil fuels and environmental issues- Introduction to Biofuels and its promises-Various types of Biofuels its classification and applications-Importance and types of feed stocks, Biomass and raw materials for Biofuels-1st 2nd and 3rd generation Biofuels.

Module-2: [8]

Biochemical Pathways and Biosynthesis of Fuels: Different energy harvesting biochemical pathways & their exploitation to Biofuels –Fermentation strategies: Aerobic & Anaerobic for Biofuel production with examples-Microbial modelling and Metabolic Engineering for Biofuel Production-Algae for oil production.

Module-3: [8]

Industrial Biofuel Production: Production strategies for various Biofuels: Bioethanol, Biobutanol and other alcohols, Biodiesel, Hydrogen, Methane-Raw material conversion to Biofuels: Pre-treatment methods, Enzymology for biomass utilization, Transesterification and Thermal depolarization-Experiments on biomass Pre-treatment: Mass balances and yields-Industrial scale ups, Technology development for Biofuel production.

Module-4: [8]

Biorefining and Standardization: Inhibitors and detoxification: Impact on biomass conversion-Bio refining of Biofuel residues-Biofuel properties, specifications and guidelines-Biomass fuel cycle methodology-Terminal operations.

Module-5: [8]

Biofuel Economics: Alternate fuels: global & Indian scenario-Feedstock economics, Biofuels demand and supply-Clean air/energy policy act-Environmental assessments -Biofuels economics and policy,Boutique fuels.

BOOK RECOMMENDED:

1. Sameer A Zogdekar, "Biofuels Introduction and Country Experiences", Published by ICFAI University Press., ISBN No. 978-8131416051, 2008.
2. David M Mousdale, "Biofuels: Biotechnology, Chemistry and Sustainable Development", Published by Taylor And Francis Group CRC Press., ISBN No.978-1439812075, 2008.
3. Alain A Vartes, Nasib Qureshi, "Biomass to Biofuels: Strategies for Global Industries", Published by John Wiley & Sons Ltd., ISBN No. 978-0470513125, 2009.

REFERENCE BOOKS:

1. David Pimentel, "Biofuels, Solar and Wind as Renewable Energy Systems", Published by Springer-Verlag., ISBN No. 978-9048179459, 2010.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	✓
Tutorials/Assignments	✓
Seminars	✓

Mini projects/Projects	
Laboratory experiments/teaching aids	✓
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	✓
Simulation	

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	10	15		
End Sem Examination Marks	12	15	13	10
Assignment*	**3**	5	7	5

* Best of two quiz: Quiz 1-CO2 & CO3; Quiz 2: CO4 & CO5 + Seminar (5 marks): best of two

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3					2						
2	3		3		2	2						
3	3		3			2						
4	3		3			2						
5			3			2						
6		3							2	2		1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2 and

				CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3 and CD8
CD3	Seminars		CO3	CD1, CD2, CD3 and CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3 and CD8
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE319
Course title: **Bioelectronics-Concept and Instrumentation**
Pre-requisite(s): EE101 Basic Electrical Engineering
Co- requisite(s): BE215 Cellular Electrophysiology
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level:
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

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

Course Outcomes

After the completion of this course, students will be:

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

Syllabus

Module-1: General Physiology [8]
Physiology of cardiac system, pulmonary system, urinary system, nervous system and muscles. Generation and propagation of action potentials in muscle, heart and nervous system.

Module-2: Electrophysiological Devices [8]
Electrocardiograph; Electromyograph; Electroencephalograph; Phonocardiograph; Plethysmograph; Pulmonary function test devices; Blood pressure and flow measurement.

Module-3: Assistive, Therapeutic and Surgical Devices [8]
Pacemaker; Defibrillator; Anesthesia machine; Ventilator; Heart-Lung machine; Hemodialysis machine; Audiometry and Hearing aids; Nerve and Muscle stimulators; Therapeutic and Surgical diathermies.

Module-4: Medical Imaging Systems [8]
Generation of X-ray; X-ray imaging device; Catheterization system; Computer Assisted Tomography; Generations of Computer Assisted Tomography System; Ultrasound and Doppler equipment; Magnetic Resonance Imaging device; Functional Imaging with Gamma camera; Single Photon Emission Tomography; Positron Emission Tomography.

Module-5: Biotelemetry Systems [8]
Antennas for biomedical application; Physiological telemetry; Radio Telemetry system; Portable telemetry system; Land-line telemetry system.

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.
3. Medical instrumentation, Application &Design by J. G. Webstar, 4th edition, Wiley Student Edition, New Delhi, 2009.
4. Introduction to Biomedical Equipment Technology by J. J. Kar and J. M. Brown, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016.

Reference Books:

1. Biomedical Engineering and Instrumentation, Basic Concepts and Applications by J. D. Bronzino, 1st Edison, PWS Publishers, Boston, 1986.

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
3. Industrial visits

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

1. Lecture on brain-computer interaction
2. Lecture on specialized imaging devices

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√		√	√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i		3		2				1				
ii	3	3	3	3						3		3
iii	3	3	3	3						3		3
iv	3	3				2	2					1
v					3		2		3		2	3

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO2	CD5

COURSE INFORMATION SHEET

Course code: BE320
Course title: Biotreatment of Municipal and Industrial Waste
Pre-requisite(s): CE101 Environmental Sciences, BE303 Mass Transfer Operations
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: 3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To familiarize students with the nature of wastes and their impact on the environment.
B.	To develop the students abilities to analyze and design systems for the collection, handling, treatment and utilization of wastes.
C.	Understand modern treatment technologies and regulations as well as sustainability of the chosen technology
D.	Student will be able to apply this knowledge to address new questions
E	To acquire in-depth knowledge of the management of treatment of wastes biologically , including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes

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

1.	Use appropriate methods for testing water and wastewater.
2.	Understand solid waste disposal methods and the advantages as well as disadvantages of the methods.
3.	Formulate and integrate processes to treat water and wastewater including food processing wastewater in order to meet the effluent discharge requirements.
4.	Demonstrate skills in analytical and critical thinking as well as problem solving abilities.
5.	Able to design the waste water treatment plants.

Syllabus

Module-I **[8]**

Definition of waste, and its classification in the context of EU legislation, Principles and Microbiology of waste water treatment-Physical, chemical and biological characteristics of waste water, BOD, COD

Module-II **[8]**

Philosophy of treatment; Unit operations and processes; Physical, chemical and biological methods Primary Treatment: Screening, Commutation, Grit removal, removal of oil and grease.

Module-III **[8]**

Secondary treatment:

Aerobic processes of secondary treatment– activated sludge, lagoons, stabilization ponds, suspended growth, nitrification, trickling filters, rotating biological contactors, anoxic suspended growth and fixed film denitrification.

Anaerobic processes of secondary treatment – biological concepts, suspended growth and fixed film processes and reactor configuration, Sequential batch reactor for combined processes (aerobic and anaerobic)

Module-IV [8]

Tertiary Treatment: Effluent disposal and reuse. Emerging biotechnological processes in waste water treatment for municipal, industrial waste waters.

Module-V [8]

Solid waste management and control- landfills, recycling and processing of organic residues, minimal national standards for waste disposal, composting technologies. Designing aspects of Wastewater treatment plant

Text Books Recommended: (T)

Ram Chandra, Environmental waste management

Metcalf and Eddy Inc., Waste water engineering

Reference Book: (R)

N.P. Cheremisinoft, Biotechnology of waste water treatment.

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	15	10			
Faculty Assessment	2	2	1		
End Sem Examination Marks	10	10	10	10	10
Assignment+ Seminar*(best of two quizzes)	8*	7*	8@	7@	

***Quiz I – CO1 & CO2**

@Quiz II - CO 3 & CO4

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3									
2	3			3	2	2						
3				3	2		2					
4			3	3				2	2			
5					2		3		3	3	3	2

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE321
Course title: CHEMINFORMATICS
Pre-requisite(s): BE204 Biochemistry and Enzyme Technology, BE205 Basics of Bioinformatics, BE304 Reaction Engineering
Co- requisite(s): Knowledge of computer database
Credits: 3 L: 03 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VI/3
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	An ability to work on basic science as well as biotech/pharmaceutical industry in multidisciplinary teams and independently.
B.	Learn various aspects to design and validate new drug-like molecules, measurements and interpreting experimental data from biological system and addressing the challenges associated with the interaction between small molecules and body system.
C.	Grab the theoretical knowledge, parameters for searching and designing pharmacophore model for a particular disease related protein in biological research/ biotechnology/ pharmaceutical in industry and research lab.
D.	Enable students to understand the processes associated with quantative structure activity Relationship (QSAR), COMFA, virtual screening, ADMET and combinatorial chemistry
E.	A master degree in this field prepares a student for careers in biotech/ pharmaceutical research in different domains including industry.

Course Outcomes

After the completion of this course, students will be:

1.	An ability to apply knowledge and to design, analyze and conduct experiments, related to domain of drug designing.
2.	An ability to validate new drug-like molecules. Know how to meet the desired needs within realistic constraints, such as, economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
3.	An ability to apply the knowledge to find various parameters for searching and designing pharmacophore model for a particular disease related protein in biological research/ biotechnology/ pharmaceutical in industry and research lab.
4.	An ability to understand the processes associated with quantative structure activity Relationship (QSAR), COMFA, virtual screening, ADMET and combinatorial chemistry.
5.	A Master degree in this field prepares a student for careers in higher education, as well as

	in pharmaceutical and biotechnology industries in governmental and private agencies. An ability to function in multidisciplinary teams. An ability to identify, formulate, and solve engineering problems.

Syllabus

Module 1: [8]

Introduction to chemoinformatics, Common public domain databases used in chemoinformatics research, Computer representation and searching of chemical structures: 2D and 3D molecular structures, Graph theoretical representations of molecules and substructure searching, Conformation generation for small Molecules, Distance keys.

Module 2: **[8]**

Concept of 3D pharmacophore and methods for deriving 3D pharmacophores, Pharmacological properties and global properties of small molecules, Lipinski's rule

Module 3: **[8]**

Molecular descriptors: Different 2D and 3D descriptors, Concept of chemical similarity and distance metrices- using 2D and 3D descriptors, Quantative structure activity Relationship (QSAR): 2D and 3D QSAR, QSPR, COMFA

Module 4: [8]

Data mining techniques for high throughput screening data, Chemical compound libraries and virtual screening, Protein ligand docking and scoring

Module 5: [8]

Computational prediction of ADMET properties, Design of virtual combinatorial libraries

Textbook:

Andrew R. Leach, Valerie J. Gillet, An Introduction to Chemoinformatics. Publisher:Springer; 1st edition (May 1, 2003) Language: English ISBN-10: 1402013477 ISBN-13: 978-1402013478

Reference books:

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Two Quiz (s)	20
End Sem Examination Marks	50
Assignment	05
Mid sem	25

Assessment Components	CO1	CO2	CO3	CO4	CO5
Two Quiz (s)	08	08	10	10	08
End Sem Examination Marks	08	08	10	10	09
Assignment	08	08	07	08	08
Mid Sem	07	09	08	05	05

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	2	j	k	l
1	3	3		3	3	2	2		2	2		
2		3	3		3		2	2	2	2		

3	3	3		3	3	2	2	2	2	2		
4	3	3		3	3	2	2	2		2		2
5	3	3		3	3	2	2	2		2	2	2

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8, CD9
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8, CD9
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD3, CD8, CD9
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE322
Course title: Biosignal Acquisition and Analysis
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: Vth (minor)/3
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge on biomedical signal acquisition.
B.	To learn the technicality associated with instrumentation and design of basic biosignal equipment.
C.	To record and analyse the engineering aspects for safety and hazards associated with biosignal recording.
D.	To record and interpret the characteristics of different biosignals.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the components of man-machine interaction.
2.	Understand the fundamentals of the concept and design of biosignalrecorder.
3.	Identify the electrical hazards associated with biosignal recording so that the safety equipment can be devised or suggested.
4.	Analyse the characteristics and features of biosignals under different events.
5.	Work in an interdisciplinary team.

Syllabus

Biosignal Acquisition and Analysis

Module-1: **Concept and Factors in Data Acquisition**: Category and factors in measurement, biometrics, problems encountered in measuring a living system, Electrical safety considerations, Types of bio-signal and its sources. [8]

Module-2: ***Sensors and Transducers***: Electrodes for bio-physiological sensing, Transducers and sensors in biological applications, Recording problems and its remedy. [8]

Module-3: ***Bioelectric amplifiers and filters***: Different types of amplifiers and their principles of operation, Types of filters and their applications. [8]

Module-4: Recording and digitization of signals: Types of recorder, analog and digital filters, Concept of analog to digital conversion. [8]

Module-5: ***Biosignal Analysis***: Interpretation of electrocardiogram, electromyogram and electroencephalogram; Special techniques in analysis of biosignals. [8]

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

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

1. Lecture on specialized physiological sensing
2. Lecture on human-machine interaction

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods

Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√		√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3			2								
2		3	3	3	2	2						
3	3				3	2		3	2		2	
4				3	3				2	2		2
5									3	2	3	

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO4	CD5

COURSE INFORMATION SHEET

Course code: BE323
Course title: **Applied Anatomy and Physiology**
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: Vth (minor)/3
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart basic knowledge on anatomy and physiology to interdisciplinary and applied engineering areas.
B.	To understand working principles of vital organ and organ systems.
C.	To learn and correlate the engineering concepts associated with the physiological processes.
D.	To record and analyse the physiological characteristics of living system.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the anatomical structure of different organs.
2.	Learn the working principles of major human organ and organ systems.
3.	Analyse and correlate the function of different physiological systems.
4.	Evaluate the characteristics of living system using electrophysiological approaches.

Syllabus

Applied Anatomy and Physiology

Module-1: Characteristics of blood; Blood cells and their role in immunity; Hemostasis and physiology of blood clotting. Muscle Tissues: Anatomy, types of muscles, physiology of muscle contraction, generation of action potential, rhythmicity of cardiac muscle contraction, properties of skeletal and Cardiac muscles. [8]

Module-2: Cardiopulmonary Syatem: Anatomy of heart and blood vessels, origin and conduction of heart beat, cardiac cycle, electrocardiogram, blood pressure, control of cardiac cycle. Respiratory System: Anatomy of respiratory system, physiology of respiration in the alveolar and tissue capillaries, control of respiration. [8]

Module-3: Digestive system: Anatomy of digestive system, nerve and blood supply, physiology of digestion. Metabolism of carbohydrates, proteins and fats; Energetics and metabolic rate; Regulation of body temperature. [8]

Module-4: Kidney and Urinary system: Anatomy of urinary system and kidney, physiology of water and electrolyte balance, acid-base regulation. [8]

Module-5: Neuron, anatomy and function of different parts of brain, spinal cord, autonomic nervous system; Motor and integrative neurophysiology; Special sense organs for taste, smell, sight and hearing. Hormones, their control and metabolism; Biological control concept and feedback mechanism. [8]

Text Books

1. Text book of Medical Physiology by Guyton & Hall
2. Anatomy and Physiology by Wilson and Wangh

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
3. Industrial visits

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

1. Lecture on specialised techniques in electrophysiological recordings
2. Lecture on specialized electrophysiological devices

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4
Mid Sem Examination Marks	√	√	√	√
End Sem Examination Marks	√	√	√	√
Assignment	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i	2	3										
ii		2	3	3	3				2	2		
iii				3	3	2			2	2	2	3
iv		2		3	3	2		2	3			

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO3	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO4	CD5

COURSE INFORMATION SHEET

Course code: BE324
Course title: Electrophysiology lab
Pre-requisite(s):
Co- requisite(s):
Credits: 1.5 L: 0 T: 0 P: 3
Class schedule per week: 03
Class: B.Tech
Semester / Level: Vth (Minor)/3
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge on biomedical signal acquisition.
B.	To learn the technicality associated with instrumentation and design of basic biosignal equipment.
C.	To record and analyse the engineering aspects for safety and hazards associated with biosignal recording.
D.	To record and interpret the characteristics of different biosignals.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the components of man-machine interaction.
2.	Understand the fundamentals of the concept and design of biosignal recorder.
3.	Identify the electrical hazards associated with biosignal recording so that the safety equipment can be devised or suggested.
4.	Analysing a biosignal recorder.
5.	Work in an interdisciplinary team.

List of Experiments

Electrophysiology Lab

Experiment 1: To Study of electrical and electronics components and instruments.

Experiment 2: To study different types of electrodes and sensors used in bio-potential recordings.

Experiment 3: To record and analyse different types of noises in biosignals.

Experiment 4: To apply and analyse the effect of different digital filters in removing noises from electrocardiogram.

Experiment 5: To apply and analyse the effect of different digital filters in removing noises from electromyogram.

Experiment 6: To apply and analyse the effect of different digital filters in removing noises from electroencephalogram.

Experiment 7: To distinguish different bands of electroencephalogram using application of different filters.

Experiment 8: To analyse the characteristics of different types of electrolytic medium between electrode and body.

Experiment 9: To separate out different heart sounds from phonocardiogram.

Experiment 10: To perform an experiment in evaluating FFT of different recorded biosignals.

Experiment 11: To perform an experiment in evaluating PSD of different recorded biosignals.

Experiment 12: To correlate the different body activities with variable assigned task.

Text Books:

4. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown
5. Handbook of Biomedical Instrumentation by R. S. Khandpur
6. Biomedical Instrumentation and Measurement by L. Cromwell et al.

Reference Books:

3. Biomedical Digital Signal Processing by W. J. Tompkins
4. 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

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

1. Lecture on specialized physiological sensing
2. Lecture on human-machine interaction

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Laboratory experiments/teaching aids (CD5)
Mini projects/Projects (CD4)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Assessment Components	CO1	CO2	CO3	CO4
Progressive Examination Marks	√	√	√	√
End Sem Examination Marks	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i	3	3			3					3	3	
ii	3	3		3	3					3	3	
iii		3		3	3				3	3	3	
iv		3			3			3	3	3	3	

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO2 and CO3	CD1
CD5	Laboratory experiments/teaching aids		CO1, CO2, CO3 and CO4	CD5
CD4	Mini projects/Projects (CD4)		CO1, CO2, CO3 and CO4	CD4

COURSE INFORMATION SHEET

Course code: BE325
Course title: **Medical Electronics and Devices**
Pre-requisite(s): BE322 Biosignal Acquisition and Analysis
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B.Tech.
Semester / Level: VI (Minor)/3
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

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

Course Outcomes

After the completion of this course, students will be:

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

Syllabus

Medical Electronics and Devices

Module-1: Bioelectric Recorder: Factors in making measurement, Electrocardiography (ECG), Electromyography (EMG), electroencephalography (EEG), evoked potentials analysis. Electroretinograghy (ERG), Electro-Oculography (EOG). [8]

Module-2: Cardiopulmonary Devices: Holter recorder, patient monitoring system, phonocardiography, blood pressure measurement, pulse plethysmography, Blood flow and cardiac output measurement, Ventilators, Anesthesia machine, Capnograph, Spirometry, Pulmonary function analyzers, Pneumotachometers. [8]

Module-3: Therapeutic Devices: Pacemekers, Defibrillators, Physiotherapic diathermies, nerve and muscle stimulator, electroshock therapy. Medical linear accelerator, Co60 Machine. [8]

Module-4: Surgical Devices: Surgical diathermy, Heart lung machine, extra corporeal membrane oxygenator, intra-aortic balloon pump, surgical laparoscopy, lithotripsy, Sterilization equipment. [8]

Module-5: Analytical Instruments: Blood Cell counter, Biochemical analysers. [8]

Text Books:

5. Textbook of Medical Physiology by A. C. Guyton, 8th edition, Prism Indian Publication, Bangalore, 1991.
6. Handbook for Biomedical instrumentation by R. S. Khandpur, 3rd edition, McGraw Hill Education (India) Pvt. Ltd., New Delhi, 2014.
7. Medical instrumentation, Application &Design by J. G. Webstar, 4th edition, Wiley Student Edition, New Delhi, 2009.
8. Introduction to Biomedical Equipment Technology by J. J. Kar and J. M. Brown, 4th edition, Pearson India Education Services Pvt. Ltd., Noida, 2016.

Reference Books:

2. Biomedical Engineering and Instrumentation, Basic Concepts and Applications by J. D. Bronzino, 1st Edison, PWS Publishers, Boston, 1986.

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
5. Industrial visits

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

3. Lecture on human-computer interaction
4. Lecture on specialized imaging devices

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Quiz Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i		3		2				1				
ii	3	3	3	3						3		3
iii	3	3	3	3						3		3
iv	3	3				2	2					1
v					3		2		3		2	3

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO2	CD5

COURSE INFORMATION SHEET

Course code: BE326
Course title: Imaging Techniques in Healthcare
Pre-requisite(s): BE322 Biosignal Acquisition and Analysis
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B.Tech.
Semester / Level: VIth (Minor)
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge for interdisciplinary science and technology.
B.	To understand the physics of medical imaging systems.
C.	To learn the technicality associated with imaging instrumentation.
D.	To understand the aspects of applications of different imaging modalities.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the general physics in imaging systems.
2.	Learn and understand the instrumentation of different image acquisition systems.
3.	Process and analyse the anatomical and physiological images.
4.	Analyse the radiation hazards and its prevention.

Syllabus

Imaging Techniques in Healthcare

Module-1: Fundamental of X-Ray: X-Ray Generation and Generators, control, Interaction between X-Rays and matter, Intensity of an X-Ray, Attenuation, Beam Restrictors and Grids, Intensifying screens, X-Ray detectors. [8]

Module-2: Applications of X-Ray: X-Ray radiography, Fluoroscopy, Digital radiography, Angiography, Cardiac catheterization lab., Computed tomography, X-Ray image characteristics, darkroom accessories and film processing. [8]

Module-3: Ultrasound Imaging: Acoustic propagation, Attenuation, Absorption and Scattering, Ultrasonic transducers, Transducer Arrays, A mode, B mode, M mode and TM mode scanners, Tissue characterization, Color Doppler flow imaging, Echocardiography. [8]

Module-4: Radio Nuclide Imaging: Interaction of nuclear particles and matter, Nuclear sources, Radionuclide generators, Nuclear radiation detectors, Rectilinear scanner, scintillation camera, SPECT, PET. [8]

Module-5: Magnetic Resonance Imaging: Angular momentum, Magnetic dipole moment, Magnetization, Larmor frequency, Rotating frame of reference, Free induction decay, Relaxation times, Pulse sequences, Generation and Detection of NMR Imager. Slice selection, Frequency encoding, Phase encoding, Spin-Echo imaging, Gradient-Echo imaging, Imaging safety: Biological effects of ionizing and non-ionizing radiations. [8]

Text Books

1. Hand Book of Biomedical Instrumentation by R S Khandpur, Tata McGraw Hill Publication, Second Edition
2. Principles of Medical Imaging by K Kirk Shung, Michael B Smith &Benjamim M W Tsui, Academic Press Inc.
3. Medical Imaging Signals and Systems by Jerry L Prince & Jonathan M Links, Pearson Prentice Hall

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

POs met through Gaps in the Syllabus

6. Conducting presentations in group and writing reports
7. Giving assignments to the students on some relevant topics
8. Industrial visits

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

5. Lecture on advance imaging modalities

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4
Quiz Examination Marks	√	√	√	√
End Sem Examination Marks	√	√	√	√
Assignment	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i	3			3		3						
ii		3		3	2	2					2	
iii				3	2	3			2		2	
iv	3		3	3								

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	Course Delivery methods		Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO3	CD2

COURSE INFORMATION SHEET

Course code: **BE327**
Course title: **Signal Processing lab**
Pre-requisite(s): BE324 Electrophysiology Lab
Co- requisite(s):
Credits: 1.5 L: 0 T: 0 P: 3
Class schedule per week: 03
Class: B.Tech.
Semester / Level: VIth (Minor)
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge on biomedical signal acquisition.
B.	To learn the technicality associated with instrumentation and design of basic biosignal equipment.
C.	To record and analyse the engineering aspects for safety and hazards associated with biosignal recording.
D.	To record and interpret the characteristics of different biosignals.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the components of man-machine interaction.
2.	Understand the fundamentals of the concept and design of biosignal recorder.
3.	Identify the electrical hazards associated with biosignal recording so that the safety equipment can be devised or suggested.
4.	Analysing a biosignal recorder.
5.	Work in an interdisciplinary team.

List of Experiments

Biomedical Signal Acquisition and Processing lab

Experiment No. 1 Display of static and moving ECG.

Experiment No. 2 Down sampling & up-sampling of ECG signal.

Experiment No. 3 Detection of QRS complex and heart rate measurement.

Experiment No. 4 Auto-correlation and cross correlation of ECG signals.

Experiment No. 5 DCT and IDCT of ECG signal.

Experiment No. 6 Computation of Convolution and Correlation Sequences.

Experiment No. 7 Signal Averaging to improve the SNR.

Experiment No. 8 PSD estimation for ECG, EEG and EMG.

Experiment No. 9 Design of 50 Hz notch filter for ECG signal and display PSD.

Experiment No. 10 Design of IIR filters for ECG (LPF, HPF, BP).

Experiment No. 11 Design of FIR filters for ECG (LPF, HPF, BP).

Experiment No. 12 Data Compression Techniques: AZTEC, TP, FAN algorithmes.

Text Books:

5. Biomedical Digital Signal Processing by W. J. Tompkins
6. 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

9. Conducting presentations in group and writing reports
10. Giving assignments to the students on some relevant topics

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

6. Lecture on specialized physiological sensing
7. Lecture on human-machine interaction

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Laboratory experiments/teaching aids (CD5)
Mini projects/Projects (CD4)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Progressive Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i	3							3				
ii	3	2	2		2				2		2	
iii	3	3	3		2				3		3	
iv	3	3	3		3				3		3	
v					3			3	3	3	3	

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2 and CO3	CD1
CD5	Laboratory experiments/teaching aids		CO4 and CO5	CD5
CD4	Mini projects/Projects (CD4)		CO1, CO2, CO3, CO4 and CO5	CD4

Course code: BE328
Course title: Molecular Simulation of Biomolecules
Pre-requisite(s): BE322 Biosignal Acquisition and Analysis
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 04
Class: B.Tech.
Semester / Level: V -VI (In-depth Specialization in Computational Biotechnology with B. Tech (Biotechnology))
Branch:
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge on Molecular Simulation of Biomolecules.
B.	To learn the technicality associated with instrumentation and design of basic Molecular Simulation of Biomolecules
C.	To perform and analyse the engineering aspects for Molecular Simulation of Biomolecules.
D.	To record and interpret the characteristics of data obtained about Molecular Simulation of Biomolecules.

Course Outcomes

After the completion of this course, students will be:

1.	To endow students with key features of molecular modelling and simulation techniques.
2.	To develop the query about the importance of simulation nowadays in different application.
3.	Detail information on stages, types and rationalism of the subject matter.
4.	Development of useful tools for automation of complex computer jobs, and making these tools accessible on the network
5.	Application to pharmaceutical research and development unit for vaccine and drug designing.

BE328 **Molecular Simulation of Biomolecules**

Module 1: Basics of Molecular Modelling and Simulation Studies, Molecular Mechanics: Concepts of Force-field, PE representation, Energy minimization techniques [8]

Module2: Simulations techniques : Molecular Dynamics, Monte Carlo Simulations [8]

Module 3: Optimization algorithms: Steepest descents, Conjugate gradient, Simulated Annealing [8]

Module 4: Different Forcefields: AMBER, CHARMM, GROMACS [8]

Module 5: Molecular Docking: Methods and Scoring Functions, AutoDOCK, Analysis and prediction of protein-ligand complexes, Quantitative assessment of binding interactions: free energy calculations [8]

Textbook:

1. ***Molecular Modelling: Principles and Applications, 2nd Edition (Illustrated)*** byAndrew R. Leach, Addison-Wesley Longman Ltd, (February 2001) ISBN: 0582382106

Reference:

1. ***Guidebook on Molecular Modeling In Drug Design (Illustrated),*** J. G. Vinter, Mark Gardner (Editor), J. G. Vinter (Editor), CRC Press (May 1994) ISBN: 0849377722

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Progressive Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	3								
2	3	3			3		3	3				

3			3	3	3	3				2		
4					3	3	3				2	1
5					3				1	2	2	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects		CO1	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO2	CD1
CD6	Industrial/guest lectures		CO2 and CO3	CD7
CD7	Industrial visits/in-plant training		CO3	CD7
CD8	Self- learning such as use of NPTEL materials and internets		CO2	CD8 and CD9
CD9	Simulation		CO3	CD6 and CD7

Course code: BE329
Course title: Perl & Bioperl Programming
Pre-requisite(s):
Co- requisite(s):
Credits: 4 L: 3 T: 1 P: 0
Class schedule per week: 04
Class: B.Tech.
Semester / Level: V/3
Branch: In-depth Specialization in Computational Biotechnology with B. Tech (Biotechnology)

Course Objectives

This course enables the students:

A.	Familiarity with AIX/UNIX or Windows operating systems, Proficiency with a text editor, such as vi or emacs
B.	Understand the syntax and semantics of the Perl language, understand how to develop and implement various types of programs in the Perl language
C.	Introduces the extensive module library, with particular attention to using Perl for working with databases.
D.	Various forms of data representation and structures supported by the Perl language
E.	Introduction to the storage, representation, integration, analysis, and retrieval of bioinformatic data (annotation, sequence and structural information)

Course Outcomes

After the completion of this course, students will be:

1.	Looking for a powerful programming environment
2.	Become familiar with the use of a wide variety of internet applications, biological database and will be able to apply these methods to research problems
3.	Development of useful tools for automation of complex computer jobs, and making these tools accessible on the network

Syllabus

Module1: Advanced Unix commands-Introduction-ls-cat-more-, Advanced Unix commands-mv-rm-rmdir-uniq-sort,Advanced Unix commands-grep. [8]

Module 2: Introduction and basic syntax, Data types: Scalar, Array, List, Hash, anonymous data types, references, special variables, common built-in scalar, array and hash functions. [8]

Module 3: Regular Expressions, Basic input/output, File handling and File and directory manipulations, Complex data structures using references. [8]

Module 4: Object oriented perl: Scope of a variable, Subroutines, Modules and packages, Objects ,classes, methods, inheritance, polymorphism. [8]

Module 5: CGI-Programming: Passing parameters and Interaction with web and databases, Use of common CPAN modules, Bioperl Introduction, Objects and Classes, Applications: Sequences, Alignments, BLAST analysis. [8]

TEXTBOOKS

1. Harshawardhan P Bal, Perl Programming for Bioinformatics, Tata McGraw Hill, 2003.
2. James Tisdall, Mastering Perl for Bioinformatics, O'Reilly, 2003.

Reference books:

1. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Benjamin- Cummings Pub Co (Sept 2002, ISBN 0805346333)

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3
Quiz Examination Marks	√	√	√
End Sem Examination Marks	√	√	√
Assignment	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	x		x							X		
2		x		x			x	x	x			
3					X						x	x

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

Course code: BE330
Course title: Biosequence analysis and Programming lab
Pre-requisite(s): BE322 Biosignal Acquisition and Analysis
Co- requisite(s): BE328, BE329
Credits: 1.5 L: 0 T: 0 P: 3
Class schedule per week: 03
Class: B.Tech.
Semester / Level: V/3th (Minor)
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To focus on the data analysis approach and its principles.
B.	Exploring the facts of protein structure, levels of structures, domain, motifs and super secondary structures and its involvement in protein folding
C.	Genomics study with gene structure and its application in protein expression.
D.	Detail knowledge on clustering approach and how applicable to biological problem.
E.	Helps in mixing the concept of algorithms and literature of computer science with biotechnology

Course Outcomes

After the completion of this course, students will be:

1.	Competent with mathematics, science, engineering fundamentals & specialization- a multidisciplinary domain
2.	Accustom with different software's and tools for Big data analysis, helpful for summer training and internships
3.	Enhance the problem solving skill for societal benefit.
4.	Be ready with the Placement in any data analysis centre, specific to biotechnology and pharmaceutical industry.

List of Experiments:

1. Pairwise sequence Alignment: BLAST and FASTA, Multiple Sequence alignments: Clustal W/X and web based programs
2. Accessing Online Bioinformatics Resources, Database Searching Techniques: NCBI, EBI, DDBJ.
3. To study protein secondary structure prediction
4. To search motifs and domain analysis

5. To study protein tertiary structure prediction by homology modeling
6. To validate and verify modeled structure through different online tools
7. Linux and Unix OS: Overview, Installation and System handling commands
8. Working with Internet: WWW, TELNET, FTP
9. Phylogenetic analysis using Phylip (various analysis and drawing rooted and unrooted trees)
10. C Programming : Windows and Linux platform

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3		3		2				2		1
2			3	3				2				1
3	3				2					2	1	1
4		3	3						2		1	1

COURSE INFORMATION SHEET

Course code: BE331
Course title: Biochemistry & Microbiology
Pre-requisite(s):
Co- requisite(s): None
Credits: 4 L:3 T:1 P:0
Class schedule per week: 04
Class: B. Tech.
Semester / Level: 5/03
Branch: Biotechnology Minor to B.Tech (Other than Biotechnology)
Name of Teacher:

Course Objectives

This course enables the students to:

A.	Learn the basic concept of biomolecules, associated metabolic processes and bioenergetics.
B.	Gain knowledge about the various microbial process, microbial culture maintenance and propagation techniques.
C.	Extend comprehensive knowledge about microbial process, media constituents, formulations and microbial growth in different fermentation mode
D.	Familiarized with the use of microorganism in environmental process, agriculture and medical field.

Course Outcomes

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

CO1	Describe the biochemistry of cells and importance of biomolecules in various anabolic and catabolic processes as well can explain the morphological features of microbes.
CO2	Acquainted with various metabolic processes of cells and microbial culture techniques.
CO3	Manipulate the microbial growth and process to produce the desired product and role of microbes in management of waste plant biomass and apply the knowledge in designing microbe based industrial processes.
CO4	Develop the interdisciplinary capacity for application of microbial cells and products in human welfare.

SYLLABUS

Module-1:

Biomolecules: Structure of nucleic acids, DNA Organization, Basic organization of Gene- lac operon, structure of m-RNA and t-RNA; Classification, Structure and function of carbohydrates; Classification and structure of standard amino acids, Physicochemical properties of amino acids; Structure of proteins, Classification and functions of lipids, Essential fatty acids. Energy rich compounds like Phosphoenolpyruvate, 1,3-Bisphosphoglycerate, Thioesters, ATP. [8]

Module-2:

Metabolic Process: Bioenergetics, Glycolysis, Gluconeogenesis, Kreb's Cycle, Electron transport chain, Oxidative phosphorylation; Photosynthesis; Beta oxidation pathway; Enzymes, Mechanism of enzyme action, Enzyme kinetics; Replication, transcription and Translation. [8]

Module-3:
Microbial diversity: Cell structure and major characteristics of bacteria, fungi, algae, protozoa, viruses, Archaebacteria, Growth of Microorganisms: Nutritional and physical requirements -typical composition of medium, Growth curve. [8]

Module-4:
Microbiological techniques and Growth: Basics of microscopy**;** Pure culture isolation, cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria; Staining techniques for microorganisms; Introduction to Batch culture, Continuous culture, Synchronous growth, Fed-batch culture. [8]

Module-5:
Microbes in human welfare: Industrially important microorganism and their products; Microbes mediated environmental process, Bioleaching, Bioremediation, Biofiltration; Microbes in agriculture; Medical microbiology, Diseases caused by bacteria, virus, fungi and protozoans; defense mechanism. [8]

Text Books:

1. D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, 3rd Edition (2002) McMillan North Publication.
2. Lubert Stryer, Jeremy M. Berg, John L. Tymoczko: Biochemistry Prescott, Harley, and Klein, Microbiology, 7th Ed., Tata McGraw-Hill, 2008
3. Pelczar, Chan and Krieg, Microbiology, 5th Edition, Tata McGraw-Hill, 1986
4. Frazier and Westhoff, Food Microbiology, 4th Edition, Tata McGraw-Hill, 1995

Reference Books:

1. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.

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:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects.
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

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4
Quiz Examination Marks	√	√	√	√
Faculty Assessment	√			√
End Sem Examination Marks	√	√	√	√
Assignment	√	√	√	√

Indirect Assessment –

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1.	3	3	3	2	2	1	1	2	1	1	1	1
2.	3	3	3	2	3	3	2	2	1	1	2	2
3.	3	3	3	2	3	3	2	2	1	1	2	2
4.	3	3	3	2	2	3	2	2	1	1	3	1

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

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 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, CD5,CD6,CD7

COURSE INFORMATION SHEET

Course code: **BE401**
Course title: Professional Practice, Law & Ethics
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L: 2 T: 0 P:0
Class schedule per week: 02
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart the knowledge basic guidelines of professional practice, Law and ethics.
B.	To become aware of code of conduct, ethical rights and underlying policies.

Course Outcomes

After the completion of this course, students will be able

1.	To exercise the good code of conduct and practices in social and professional domain of life.
2.	To develop the skill to use the animal judiciously and utilitarian way.
3.	To practice the biotechnology following the national as well as international guidelines and policies.

Syllabus

Module I **[6]**

Introduction: Professional practice, scope of the guidelines, key terminology, risk assessment and risk management.

Module II **[6]**

Ethics: LEGAL VS. ETHICAL, Importance of ethics, Code for ethical guidelines, Ethical Principles, Ethical duties, ethics for employees: employee ethics worksheet, ethics for employers, employer ethics worksheet, disclosures.

Module III **[6]**

Ethics in profession: recognition and respect for different cultures, values and beliefs, integrity of research and product testing, care and protection of research staff, utilitarian ethic, care and protection of animals, general policy.

Module IV **[6]**

Ethical Review Process, Intellectual property and commercialisation, international obligations, Prohibited and unethical practices in biotechnology.

Module V **[6]**

Rights of an Employee, whistleblower policy**.**

Text books:

T-1: RajuRamachandran, Professional Ethics: Changing Profession and Changing Ethics (LexisNexis, Butterworths).

Reference books:

R-1: Greely, H.T., 1995, Conflicts in the biotechnology, J.Law, Med, Ethics, 23:354-59.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3		
Mid Sem Examination Marks	**10**	**15**			
End Sem Examination Marks	**10**	**25**	**25**		
Assignment	**4**	**5**	**6**		

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1			2	3			3	3	3			3
2			2	3			3	3	3			3

3			2	3			3	3	3			3

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD8
CD3	Seminars		CO3	CD1, CD2, CD8
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE 402
Course title: Bioreactor and Bioprocess Design
Pre-requisite(s): Nil
Co- requisite(s): Nil
Credits: 4 L: 3 T: 1 P:0
Class schedule per week: 04
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	The course imparts advanced knowledge on bioreactor design for efficient utilization of the principles in bioprocess technology
B.	Mixing time in agitated tanks
C.	Instrumentation and control of bioprocesses
D.	Simulations in bioprocesses

Course Outcomes

After the completion of this course, students will be:

1.	Basic concepts of bioreactor design.
2.	Non- ideal mixing and models for non -ideal reactors
3.	Scale up consideration for bioreactors
4.	Methods and strategies for fermentation control
5	Modelling and simulation of fermentation processes

Syllabus **3 Credits**

Module-1: **[8]**

Important Considerations for Bioreactors Design: oxygen transfer, heat transfer, rheology, mixing, mechanical fittings in a bioreactor, vessel, agitation system materials, welds, valves, piping

Module-2: **[8]**

Reactors with Non-ideal Mixing: Mixing time in agitated tanks, Residence time distributions, Models for non-ideal reactors, Agitation and oxygen transfer rate, Kla determination

Module-3: **[8]**

Scale Up and Scale Down Concepts: Criteria for bioreactors, Power consumption in gaseous and non gaseous systems, Case study

Module-4: **[8]**

Instrumentation and control of bioprocesses, Physical and chemical sensors, off-line analytical methods, Control of heat exchanger, distillation column and bioreactor systems

Module-5: **[8]**

Study of anaerobic & aerobic processes, Ethanol production, Acetone-Butanol production, citric acid production and penicillin production, Introduction to simulation of bioprocesses

Text Books:

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. Bioseparations: Principles and Techniques, B. Sivasankar, Prentice Hall, 2005

Reference Books:

1. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.
2. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.
3. Bioseparations: Downstream Processing for Biotechnology, Paul A. Belter, E. L. Cussler Wei-Shou Hu, Wiley India, Pvt Ltd., 1988

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	
Laboratory experiments/teaching aids	
Industrial/guest lectures	
Industrial visits/in-plant training	
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	Yes

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	C05
Mid Sem Examination Marks	√	√			
End Sem Examination Marks	√	√	√	√	√
Assignment			√	√	

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	3	3	2						1
2	3	3	3	3	3							1
3		3	3					2	2	2		1
4		3	3	3	3	2				2	2	1
5			3	3	3	2	2		2			1
												1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1,2,3,4,5	CD1

CD2	Tutorials/Assignments		CO2,3	CD1, CD8 and CD9
CD3	Seminars		CO2	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE403
Course title: Plant & Agriculture Biotechnology

Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to :

A.	Learn the fundamentals of culturing plant cells and tissues, culture environment.
B.	Gain knowledge of plant totipotency nature and its applications.
C.	Understand cell proliferation, differentiation, and learn media formulation
D.	Describe the phenomenon of Organogenesis, embryogenesis and somaclonal variation.
E.	Acquire knowledge on various recombinant DNA techniques to produce genetically modified organisms with novel traits.
F.	Impart knowledge of plant protoplast isolation, purification and culturing and understand its applications.
E.	Gain concept regarding crop improvement techniques.

Course Outcomes

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

1.	Acquire the knowledge about the techniques of Plant Tissue Culture, Lab. organization & measures adopted for aseptic manipulation and nutritional requirements of cultured tissues.
2.	Apply knowledge for large scale clonal propagation of plants through various micropropagation techniques, and Production of secondary metabolites under *in vitro* conditions.
3.	Develop skill in raising transgenics resistant to biotic & abiotic stresses & quality characteristics and their role in crop improvement.
4.	Design and implement experimental procedures using relevant techniques
5.	Work effectively individually or in a group of disciplinarians or a multidisciplinary setting

6.	Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums.
7.	Understand and practice the ethics surrounding scientific research.
8.	Understanding of societal and environmental issues and deriving a solution to a problem

Syllabus :

Credit: 3

Module-1: **[8]**

In Vitro culture: Basics about equipment's and laboratory set up, culture media components, types of culture media, gelling agents, plant growth regulators, contaminants, sterilization techniques, benefits and limitations, lab safety aspects.

Module-2: **[8]**

Callus and Suspension Culture: Types of explants, maintenance and growth pattern of callus, initiation and growth curve of suspension culture, Production of secondary metabolites, Bioreactors, Long-term storage of cultures.

Module-3: **[8]**

Micropropagation: Principles and methods of micropropagation, stages of micropropagation, Organogenesis, Embryogenesis, Artificial Seeds, Somaclonal variation, Production and use of haploids, commercial micropropagation.

Module-4: **[8]**

Protoplast, Embryo and Endosperm culture: Isolation and regeneration of protoplast, Protoplast fusion and somatic hybridization, Cytoplasmic hybridization, Principles and application of embryo and endosperm culture, Apomixis.

Module-5: **[8]**

Crop Improvement: Development of crops adaptable to stresses using *Agrobacterium* and particle bombardment mediated transformation, gene silencing and hairy root culture, Plants as factories for biopharmaceuticals, Use of nanotechnology in Agricultural sciences, Precision agriculture, Value addition in crops and sustainable agriculture.

Books Recommended:

Text Books:

1. M. K. Razdan: An introduction to plant tissue culture. Science Publishers (2003) 2nd ed.
2. Timir Baran Jha and Biswajit Ghosh: Plant Tissue Culture: Basic and Applied
3. Slater, A., Scott, N.W., and Fowler, M.R., Plant Biotechnology, Oxford University Press (2008) 2nd ed.

Reference Book:

4. A. Mizrahi, Biotechnology in agriculture
5. S. Natesh, Biotechnology in agriculture

6. Dixon and Gonzales, Plant cell culture – a practical approach.
7. Primrose, S.B. and Twyman, R.M., Principles of Gene Manipulation and Genomics, 7th Edition, Blackwell Publishing (2006) 7th ed.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	15	10				
Faculty Assessment	2	2	1			
End Sem Examination Marks	8	8	10	10	12	12
Assignment + seminar *(two quizzes)	5	5	5	5		

CO1 &CO2 for quiz 1.CO3 & CO4 for quiz 2

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3											
2	3	3	3	3	3		2					
3	3	3	3		3	2						
4	3		3			2				2	2	
5		3	3			2		2	2	2	2	
6				3			2			2		
7							2	2	2	2		1
8										2	1	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD3, CD8
CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		CO6	CD1, CD2,CD3, CD8
CD7	Industrial visits/in-plant training		CO7	CD1, CD2, CD3, CD8
CD8	Self- learning such as use of NPTEL materials and internets		CO8	CD1, CD2, CD3, CD8
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: MT204
Course title: Constitution of India
Pre-requisite(s):NIL
Co- requisite(s):NIL
Credits: 2 L: 2 T:0 P:0
Class schedule per week: 02
Class: B.Tech
Semester / Level: /2
Branch: Biotechnology
Name of Teacher:

Course Objectives:

A.	To describe the importance and role of Constitution of India
B.	To explain the provisions related to social problems and issues.
C.	To explain the significance of the constitution for maintaining social unity and integrity.
D.	To describe the process for formulating and designing public policies in accordance with the constitutional provisions.

Course Outcomes

After the completion of this course, students will be:

1.	Outline the need and importance of the Indian constitution.
2.	Explain the fundamental rights and duties of the citizens of India.
3.	Relate appropriate constitutional provisions with relevant social issues
4.	Describe the role of different departments of government.
5.	Crique the Government policies and programmes designed for the society at large.

Syllabus

Module 1: Introduction to the Constitution of India, Salient Features of the Constitution: Sources and constitutional history, Features: Citizenship, Preamble, Fundamental Rights and Duties, Directive Principles of State Policy.

Module 2: Union and State Executives: President and Prime Minister, Council of Ministers, Cabinet and Central Secretariat, Lok Sabha, Rajya Sabha. Governor: Role and Position, Chief Ministers and Council of ministers.

Module 3: The Indian Judicial System – The Supreme Court and The High Court's – composition, Jurisdiction and functions, The Role of the Judiciary.

Module 4: Local Government- District's Administration: Role and Importance, The Panchayatas – Gram Sabha, Constitution and Composition of Panchayatas , Constitution and Composition of Municipalities

Module 5: Miscellaneous- Election Commission: Role and Functioning, Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning, Institute and Bodies for the welfare of SC/ST/OBC and women.

Suggested Readings

1. The Constitution of India by " Ministry of Law India" Kindle Edition
2. Constitutional History of India by Prof.M.V.PYLEE-S.Chand Publishing
3. Indian Administration by Avasti and Avasti-Lakshmi Narain Agarwal Educational Publishers.2017 edition.
4. Introduction to the Constitution of India by D D Basu by Lexis Nexis : 20th edition.
5. Constitution of India V.N.Shukla's EBC Explorer Edition 13th ,2017

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
1.Lecture by use of boards/LCD projectors/OHP projectors
2. Tutorials/Assignments
3. Seminars
4. Mini projects/Projects
5.Laboratory experiments/teaching aids
6.Industrial/guest lectures
7.Industrial visits/in-plant training
8.Self- learning such as use of NPTEL materials and internets
9.Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	**% Contribution during CO Assessment**
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**

Mid Sem Examination Marks	√	√			
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√		

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	**Program Outcomes**				
	1	**2**	**3**	**4**	**5**
1	3	**1**	1	3	3
2	3	**3**	1	2	2
3	2	**2**	1	**3**	3
4	2	3	3	**2**	**2**
5	**1**	3	3	**1**	**2**

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1, CD2
CD4	Mini projects/Projects		CO4,	CD1, CD2
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD3, CD6
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE404
Course title: Plant Cell Technology Lab

Pre-requisite(s):
Co- requisite(s):
Credits: 1.5 L: 0 T:0 P:3
Class schedule per week: 03
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Title: Plant Cell Technology lab
Credit Points: 1.5

Course Description
This course provides knowledge of and expertise in plant tissue culture theory and practice. This course has a vocational focus and introduces students to the theory and practice of plant tissue culture with their role and applications in biotechnology.

The topics covered in this course include media preparation, sterile techniques, aseptic handling, initiation and routine maintenance of cells in culture, common contaminants of plant cell culture, and understanding of some of the applications of cell culture technology e.g. somatic cell and protoplast fusion vector mediated genetic transformations.

Pre-requisite Courses
Knowledge of and practical skills in plant and animal anatomy and physiology

Course Objectives:

On successful completion of this course you should be able to:

1. Explain major components of cell and tissue culture media, e.g. minerals, growth factors, hormones, and what governs the choice of components.
2. Explain steps taken to establish and optimize media for different species without the aid of texts.
3. Perform the common cell culture techniques, e.g. callus culture, Embryo culture and embryogenesis in plants.
4. Competently perform laboratory procedures and demonstrate practical application and conceptual knowledge of cell and plant tissue culture for biotechnology investigations and applications.

Course outcomes

1. **Understanding Science:** Articulate the methods of science and explain why current scientific knowledge is contestable and testable through further inquiry.
2. **Scientific knowledge:** Demonstrate a depth and breadth of knowledge and understanding of biological sciences.
3. **Inquiry and problem solving:** Analyse and solve problems in biotechnology by collecting, accurately recording, interpreting, and drawing conclusions from scientific data.
4. **Personal and professional responsibility:** work responsibly, safely, legally and ethically in an individual and team context.

Mapping of Cos with POs

S. No:	Name of Experiments	CO	PO
Experiment 1:	Demonstration of various instruments/equipment used in the PCT lab.	1,2	a, b, c
Experiment 2:	Preparation of Culture Media	1,2,3	a, b, c, g, i, j
Experiment 3:	Sterilization of Culture Media	2, 3,4	a, b, c,d,e, j, k
Experiment 4:	Sterilization of explant and its inoculation in culture media	3, 4	a, b, c, d,e, j, k,
Experiment 5:	Growth pattern analysis of inoculated explant	1,2,3,4	a, b, c, g, i, j, k,
Experiment 6:	Development and propagation of cell suspension culture	2,3,4	a, b, f,h, i, k, l
Experiment 7:	Preparation of synthetic seeds by encapsulation of somatic embryos in Alginate Beads	2,3,4	a, b, c,d, e, f, k,l,
Experiment 8:	Agrobacterium mediated transformation for hairy root culture.	1,2,3,4	a, b, c,d, e, f, k,l
Experiment 9:	Isolation of protoplasts, plating and regeneration	1,2,3,4	a, b, c,d, e, f, k,l

Book:

O.L. Gamborg and G. C. Phillips (Eds.): Plant Cell, Tissue and organ Culture: Fundamental methods. A Springer Lab Manual.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

COURSE INFORMATION SHEET

Course code: BE405
Course title: System Biology
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 03 T:00 P:00
Class schedule per week: 03
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

A.	To inculcate systems thinking that is integrative approach rather than reductionist approach in biology
B.	Provide the student with an understanding of the methods, tools, and limitations of *modelling and simulation of biological systems.*
C.	Help understand the design principles underlying biological systems
D.	Train students for understanding biology from an engineering perspective

Course Outcomes

At the end of the course the students are capable of:

1.	Applying knowledge of different disciplines to model a biological system at hand
2.	Identifying complex biological machineries and pathways to analyze and understand them using first principles of basic and applied sciences
3.	Reviewing literature so as to identify and analyze complex biological systems
4.	Apply tools and techniques to model complex biological systems
5.	Would be capable of having a multidisciplinary team approach resulting from the systems thinking
6.	Integrative approach towards biological systems will enable them to accept technical challenges in other areas and fronts of engineering

SYLLABUS

BE405 Systems Biology **Credits: 3**

Module I

Systems Biology: Fundamentals, Overview of Gene Control, Working of Genetic Switches, The biochemical paradigm, genetic paradigm and the systems paradigm. [8]

Module II

Kinetics: Equilibrium Binding and Co-operativity, Michaelis-Menten Kinetics, identical and independent binding sites, Identical and interacting binding sites, non-interacting binding sites.Genetic switch in Lambda Phage -Noise-based Switches and Amplifiers for Gene Expression.Synthetic genetic switches, *E.coli* chemotaxis, biological oscillators- genetic oscillators, The Origin and Consequences of Noise in Biochemical Systems. [8]

Module III

Developmental Systems Biology: Building an Organism Starting from a Single Cell, Quorum Sensing, Programmed Population Control by Cell-Cell Communication and Regulated Killing, Drosophila Development, Establishment of Developmental Precision and Proportions in the Early Drosophila embryo. [8]

Module IV

Gene expression networks: Gene regulation at a single cell level, Transcription Networks, coherent Feed Forward Loop (FFL) and delay gate, The incoherent FFL, Temporal order, Signaling networks and neuron circuits, Aspects of multi-stability in gene networks. [8]

Module V

Application of Microarrays in Life Sciences: Concepts of Microarray analysis, platforms and principles of Microarray technology, Different Markup languages used in systems biology, NGS technology. [8]

TEXT BOOKS

1. System Biology: Computational Systems Biology (Hardcover) by Andres Kriete (Editor), Roland Eils (Editor)
2. Stochastic Modelling for Systems Biology. ISBN-10 1-58488-540-8 and ISBN-13 978-158488-540-5
3. Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide By: Helen Causton (Imperial College), J Quackenbush and AlvisBrazma (The European Bioinformatics Institute)
4. A Practical Approach to Microarray Data Analysis (Hardcover) by Daniel P. Berrar (Editor), Werner Dubitzky (Editor), Martin Granzow (Editor)

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Direct Assessment

AssessmentCompoents	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination						
Faculty Assessment						
End Sem Examination						
Assignment						

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
A	3											
B		3										
C				2								
D					3							
E											3	
F												3

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE407
Course title: NANOBIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 03 T:00 P:00
Class schedule per week: 03
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To gain knowledge about the concepts, diverse applications of nanobiotechnology and its interdisciplinary aspect.
B.	To learn the principle phenomena governing the nanoscale effect on material properties and their applicability
C.	To familiarize the students with native bionanomaterials in living cells, their working and interaction with nanomaterials and how these principles can be applied to design new bionanomaterials and devices.
D.	To gain a working knowledge in nanotechnology techniques (synthesis, fabrication, characterization) and acquire the ability to use them to solve problems in bioengineering and biomedicine.
E	To correlate the impact of nanoscience and nanotechnology in a global, economic, environmental, and societal context.
F	To identify career paths at the interface of nanotechnology, biotechnology, environmental and agricultural engineering, medicine and research.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the fundamentals of nanoscience, nanotechnology and biology that are converging to create the new area of nanobiotechnology
2.	Recognize the structural and functional principles of Bio-nanotechnology and their significance in designing nanomaterials and nanodevices
3.	Acquire the knowledge on different nano-fabarication methods and characterization techniques for nanomaterials. Employ bionanomaterials for analysis and sensing techniques
4.	Familiarize themselves with nanobiotechnology potentialities and be able to apprehend and

	explain use of nanomaterials in different biomedical applications. Ability to recognize the potential concerns and measures to be taken

Module-1: **[8]**

Introduction to Nanobiotechnology: Definitions and concept of Nanobiotechnology & Historical background, Nanoscale phenomena & Properties, Nanoscale visualization and characterization techniques.

Module-2: **[8]**

Nano-Materials in Biosystems: Lipid bilayers, liposomes, polysaccharides Peptides, nucleic acids, Biomolecular Structure and Stability, Self assembly, self organization, Limitations of natural biomolecules, Cell – Nanostructure interactions.

Module-3: **[8]**

Engineered Nanomaterials: Classification based on dimensionality, synthesis, properties and applications of Carbon nanomaterials, Metal nanoparticles, Fluorescent nanomaterials (Quantum dots), Dendrimers, DNA-Gold nanoconjugates.

Module-4: **[8]**

Biogenic Nanoparticles: Overview and concept of biological nanoparticle production from plants and microbes, Methods of nanoparticle production, Advantages & Limitations to consider, applications of biological nanoparticles.

Module-5: **[8]**

Emerging Nanotechnologies: Nano labels, biosensors, nanomedicine, bioimaging, Drug delivery, Regenerative medicines, Nanotoxicology challenges, case study.

Books Recommended:

Text books:

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

Reference books:

T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd.,
2012
David S Goodsell, "*Bionanotechnology*", John Wiley & Sons, 2004

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

POs met through Gaps in the Syllabus: NA

Topics beyond syllabus/Advanced topics/Design: NA

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

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	
Mid Sem Examination Marks	√	√	√	√	**25%**
End Sem Examination Marks	√	√	√	√	**60%**
Assignment	√	√	√	√	**15%**

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	B	c	d	e	f	g	h	i	j	k	l
1	3	3										
2			3	3								
3					2	2						

4							2	2	2	2		1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE408
Course title: Mineral Biotechnology
Pre-requisite(s): NIL
Co- requisite(s): Nil
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: 7/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students to:

A.	The main aim of the course is to give a knowledge of mineral assimilation by bacteria and other microorganisms. The process of recovery from these microorganisms.
B.	The leaching of ore using Biotechnology approach, strain improvement and Identification.
C.	Bioleaching processes of low-grade ore and mechanism of Bioleaching
D.	To give a knowledge of biotechnological processing of coal and conversion into organic compounds.
E.	Use of Microbes in bioremediation and study of impact on environment.

Course Outcomes

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

1.	Demonstrate and understanding of fundamental biochemical principles and mechanism of Bioleaching.
2.	Understanding of metal assimilation and recovery from microbes.
3.	Be capable of undertaking suitable experiments/research methods in bio-leaching process.
4.	Apply and effectively communicate scientific reasoning and data analysis in both written and oral forums.
5.	Understand and practice the ethics surrounding coa and other mineral mining.
6.	Understanding of societal and environmental issues and deriving a solution to a problem.

Syllabus **Credit:3**

Module-I **[8]**

Metal-Microbe Interaction: Extracellular complexation, extracellular precipitation of metal, Metal resistance in soil bacteria, Metal extraction and recovery by microorganisms, Biosorption of metals, biosorption Kinetics, Metal recovery process

Module-II **[8]**

Biogeotechnology: Bioleaching, low grade technology, high grade technology, bioleaching of gold, copper, uranium, Mechanism of bioleaching.

Module-III **[8]**

Biomineralization: Bacterial bio-mineralization, multicellular bio-mineralization, microbiologically induced corrosion.

Module-IV **[8]**

Coal: Nature, structure and types, Bioprocessing of coal, clean coal technology, desulphurization of coal, biological conversion of coal to organic chemicals.

Module-V **[8]**

Bioreactor design: Mineral bioprocessing, Environmental control and mine site remediation, Chemistry and control of acid mine drainage.

Books Recommended:

S.K. Kawatra, Mineral Biotechnology.

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	15	10				
Faculty Assessment	2	2	1			
End Sem Examination Marks	8	8	10	10	12	12
Assignment + seminar*(best of two quizzes)	5	5	5	5		5

*CO1 &CO2 for quiz 1.CO3 & CO4 for quiz 2

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3		3									
2	3	3	3	3	3							
3	3	3	3		3	3			2			
4	3					2			2	2		
5		3	3			2		2				
6				3			2			2		1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1, CD2, CD3, CD8

CD2	Tutorials/Assignments		CO2	CD1, CD2, CD3, CD8
CD3	Seminars		CO3	CD1, CD2, CD3, CD8
CD4	Mini projects/Projects		CO4	CD1, CD2, CD3, CD8
CD5	Laboratory experiments/teaching aids		CO5	CD1, CD2, CD3, CD8
CD6	Industrial/guest lectures		CO5	
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets		CO1 and CO2	
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE409
Course title: Rehabilitation Engineering
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge for interdisciplinary, applied engineering and technology.
B.	With respect to design consideration, to understand the sensory physiology of human system.
C.	To learn the technicality associated with instrumentation and design of basic rehabilitation system.
D.	To understand the engineering aspects for challenges in designing a rehabilitation system.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the sensory physiology in nerve-motor communication system.
2.	Learn and remember the fundamentals on rehabilitation science, engineering and technology.
3.	Analyse the instrumentation requirements of rehabilitation system.
4.	Evaluate the challenges in designing support device.
5.	Designing of a system to augment disabilities.

Syllabus

Rehabilitation Engineering

Module-1: Fundamentals of rehabilitation engineering: [8]
Introduction, rehabilitation science, technology and engineering, rehabilitation engineering in sensory, motor and communication system; measurement tool and process in rehabilitation engineering.

Module-2: Types of Augmentation: [8]
Orthopedic prosthetic and orthotics in rehabilitation; externally powered and controlled orthotics and prosthetics, Introduction to Sensory-Motor augmentation; Stroke and Stroke Rehabilitation; Approaches in Human-Computer Interfaces.

Module-3: Speech and Auditory Rehabilitation: [8]
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.

Module-4: Assistive Technology in Vision: [8]
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.

Module-5: Challenges in Rehabilitation Engineering: [8]
Designing of rehabilitation system: Behavioral and learning problems in disabled; Sociolegal aspects of Rehabilitation.

Text Books

1. Textbook of Rehabilitation by S. Sunder, Jaypee Medical Publications, New Delhi.
2. Acquired Brain Injury-An Integrative Neuro-Rehabilitation Approach, Jean Elbaum Deborah M. Benson (Eds.), Springer.
3. Assistive Technology for the Hearing-impaired, Deaf and Deafblind by Marion A. Hersh, Michael A. Johnson (Eds.), Springer.
4. Assistive Technology for Visually Impaired and Blind People by Marion A. Hersh and Michael A. Johnson (Eds.), Springer.

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

11. Conducting presentations in group and writing reports
12. Giving assignments to the students on some relevant topics

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

8. Lecture on special sensory organs

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
i	H											
ii				3	3	3		2	2			
iii				3	3				2		2	
iv				2	2						3	3
v		3	3	3	3	3		2	3	3	2	

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2

COURSE INFORMATION SHEET

Course code: BE410
Course title: PROCESS MEASUREMENT & CONTROL
Pre-requisite(s): Phy, Engg Math, fundamental of electrical and electronic engg
Co- requisite(s):
Credits: 3 L:3 T:0 P:0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	Fundamental of system theory
B.	Familiar with different type of control strategy
C.	Different type of measurement
D.	Introduction of modelling of system
.E	Application of control system in process control

Course Outcomes

After the completion of this course, students will be:

1.	Understanding the fundamental of system theory
2.	Understanding the fundamental of control strategy
3.	Understanding the fundamental of operation of process control plants
4.	Understanding the fundamental of sensor, transducer and actuator

Syllabus

MODULE – I - Introduction: [8]

Basic components of control systems, Examples of control systems and applications, Open loop and closed loop control systems, Effect of feedback on overall gain, Stability and external disturbances, Classification of control system : Linear and nonlinear continuous and digital, Time invariant and time varying.

MODULE II – Block Diagrams and Signal Flow Graph: [8]

Block diagrams of control systems, Final control element, pneumatic and hydraulic controller, control valves and their characteristics, Mathematical modelling of control system, transfer functions,

MODULE – III Control System Components and Basic Control Actions: [8]

Transducers: Classification, Inductive, Resistive and Capacitive transducers, Analog and Digital Transducers with applications. Hall effect, Piezo Electric, Photovoltaic transducer, Measurement

of temperature and pressure. encoders in control system, Potentiometer, Basic control actions: on-off control, P, PI, PD and PID.

MODULE – IV Time Response of Control Systems: [8]

Transient and steady state response, Time response specifications, Typical test signals, Steady state error, and error constant,

MODULE – V Advanced control systems: [8]

multivariable control problem, ratio control, cascade control, computed variable control, feed forward control, override control, adaptive control. predictive control, Fuzzy logic control. Control of heat exchanger, distillation column, bioreactor control system analysis.

Text books: 1Control System Engineering – Nagrath & Gopal

Reference books; Coughanouer and Koppel, Process System analysis and Control Perry's Chemical Engineers
Handbook.
Gaps in the syllabus (to meet Industry/Profession requirements)

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	
Faculty Assessment	√	√	√		
Mid Sem Examination Marks	√	√			
End Sem Examination Marks	√	√	√	√	
Assignment/Quizes-02	√	√	√	√	

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	2	2	2	2	1	1	1	1	1	1
2	3	3	3	3	2	2	2	1	1	1	1	1
3	3	3	3	2	2	2	2	1	1	1	1	1
4	3	3	3	2	2	2	1	1	1	1	1	1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE411
Course title: Molecular Modelling and Drug Designing
Pre-requisite(s): BE205 Basics of Bioinformatics
Co- requisite(s):
Credits: L: 3 T: P:
Class schedule per week: 0x
Class: B. Tech
Semester / Level:VII/4
Branch: Biotechnology
Name of Teacher:

Course Objectives

This course enables the students:

A.	Describe and comprehend the fundamental concepts of molecular modeling and its technique.
B.	Provide the student with an understanding of the methods, capabilities, and limitations of *molecular simulation*.
C.	Concepts are the forces acting between the individual atoms or molecules making up the system.
D.	Advanced techniques such as Hit-to-lead optimization and Multi-conformation Docking.
E.	Different methods of drug designing will be discussed

Course Outcomes

After the completion of this course, students will be:

1.	To equip students with key skills of molecular modeling techniques currently practiced in any pharmaceutical research and development unit.
2.	Analyze and discuss the results in light of molecular biological knowledge
3.	Development of useful tools for automation of complex computer jobs, and making these tools accessible on the network

Syllabus

Module 1: Basics of Molecular Modelling, Comparative modeling of proteins: comparison of 3D structure, Homology modelling and its steps, side chain and loop modeling. Tools & databases used in protein modelling. [8]

Module 2: Molecular Mechanics: Simulation techniques: Molecular Dynamics simulation, Concepts of Force-field, PE representation, Energy minimization techniques. [8]

Module 3: Optimization algorithms: Steepest descents, Conjugate gradient, Simulated Annealing. Monte Carlo simulation: Random number generation, Difference in MD & MC [8]

Module 4: Molecular Docking: Methods and Scoring Functions, application in screening, QSAR studies [8]

Module 5: General approach to discovery of new drugs, lead discovery, lead modification. Physiochemical principles of drug action, Lipinski rule and ADMET. Computer aided drug design and its application. [8]

TEXT BOOKS:

1. A. R.Leach - Molecular Modeling Principles and Application, 2nd edition, Longman Publications, 1996.
2. Introduction to Bioinformatics by Aurther M lesk

Reference books:

1. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Benjamin- Cummings Pub Co (Sept 2002, ISBN 0805346333)

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3		
Mid Sem Examination Marks	**10**	**15**			
End Sem Examination Marks	**15**	**15**	**20**		
Assignment	**10**	**5**	**5**		

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome #	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	2	2	2	1	1	1	1	1	3
2	3	3	3	2	2	1	1	1	1	1	1	3
3	3	3	3	3	2	2	1	1	1	1	1	

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1	CD1
CD2	Tutorials/Assignments		CO2	CD1
CD3	Seminars		CO3	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			
CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE 412
Course title: Process Biotechnology
Pre-requisite(s): BE307 Bioprocess Engineering
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology & Others
Name of Teacher:

Course Objectives

This course enables the students to:

A.	Understand the basic mechanism of bacterial growth
B.	Understand the mechanism of action of enzyme
C.	Sterilize liquid medium and air
D.	Understand the process of production of different metabolites
E.	Understand the operation principle of Bioreactors

Course Outcomes

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

1.	Calculate kinetic parameters and yield from bacterial growth curve
2.	Determine the effect of parameters on enzyme kinetics
3.	Sterilize air and liquid medium
4.	Produce different primary and secondary metabolites
5.	Differentiate mode of operation of basic bioreactors

Syllabus **3 Credits**

Module 1:

Cell growth and kinetics: Pattern of growth behaviour in batch culture, factors affecting the process of growth and model for Product formation, Mass balance, Yield prediction. [8]

Module 2:

Enzyme kinetics: Introduction to enzymes, Michaelis–Menten kinetics, Linear plots. Determining rate parameters, Effect of pH and temperature, Enzyme immobilization. [8]

Module 3:

Sterilization: Importance of Sterilization, Introduction and the kinetics of death, various type of sterilization equipments, role of oxygen transfer rate. [6]

Module 4:

Production of primary and secondary metabolites: Bioprocesses for production of organic acids; solvents; antibiotics, proteins; polysaccharides; lipids etc. [8]

Module 5:

Bioreactors, **Mode of bioreactor operation:** Batch, Fed-batch and Continuous bioreactors, Operation and control of bioreactors. [6]

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

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

NIL

POs met through Gaps in the Syllabus

NIL

Topics beyond syllabus/Advanced topics/Design

NIL

POs met through Topics beyond syllabus/Advanced topics/Design

NIL

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors
Tutorials/Assignments
Seminars
Mini projects/Projects
Laboratory experiments/teaching aids
Industrial/guest lectures
Industrial visits/in-plant training
Self- learning such as use of NPTEL materials and internets
Simulation

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√			
End Sem Examination Marks	√	√	√	√	√
Assignment			√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3										1
2			3	3								1
3					2							1
4		3	3									1
5		3	3	3								1

Mapping Between COs and Course Delivery (CD) methods				
CD	**Course Delivery methods**		Course Outcome	Course Delivery Method
CD1	Lecture by use of boards/LCD projectors/OHP projectors		CO1, 2, 3, 4, 5	CD1
CD2	Tutorials/Assignments		CO3, 4	CD1
CD3	Seminars		CO5	CD1 and CD2
CD4	Mini projects/Projects			
CD5	Laboratory experiments/teaching aids			

CD6	Industrial/guest lectures			
CD7	Industrial visits/in-plant training			
CD8	Self- learning such as use of NPTEL materials and internets			
CD9	Simulation			

COURSE INFORMATION SHEET

Course code: BE413
Course title: Biomechanical Systems and Rehabilitation Engineering
Pre-requisite(s): BE325 Medical Electronics and Device
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VIIth (Minor)/4
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge for interdisciplinary, applied engineering and technology.
B.	With respect to design consideration, to understand the sensory physiology of human system.
C.	To learn the technicality associated with instrumentation and design of basic rehabilitation system.
D.	To understand the engineering aspects for challenges in designing a rehabilitation system.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the sensory physiology in nerve-motor communication system.
2.	Learn and remember the fundamentals on rehabilitation science, engineering and technology.
3.	Analyse the instrumentation requirements of rehabilitation system.
4.	Evaluate the challenges in designing support device.
5.	Designing of a system to augment disabilities.

Syllabus

Biomechanical Systems and Rehabilitation Engineering

Module-1: Fundamentals of rehabilitation engineering: [8]

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.

Module-2: Neuromuscular assessment: [8]

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.

Module-3: Sensory Rehabilitation: [8]

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.

Module-4: Assistive Technology in Vision: [8]

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.

Module-5: Challenges in Rehabilitation Engineering: [8]

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

Textbooks

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

13. Conducting presentations in group and writing reports
14. Giving assignments to the students on some relevant topics

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

9. Lecture on special sensory organs

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Components	CO1	CO2	CO3	CO4	CO5
Quiz Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	L
i	H											
ii				3	3	3		2	2			
iii				3	3				2		2	
iv				2	2						3	3
v		3	3	3	3	3		2	3	3	2	

Mapping Between Cos and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2

COURSE INFORMATION SHEET

Course code: BE414
Course title: Health Informatics and Telemedicine
Pre-requisite(s):
Co- requisite(s):
Credits: 3 L: 3 T: 0 P: 0
Class schedule per week: 03
Class: B. Tech
Semester / Level: VIIth (Minor)/4
Branch: BMI minor
Name of Teacher:

Course Objectives

This course enables the students:

A.	To impart knowledge for interdisciplinary, applied engineering and technology.
B.	With respect to design consideration, to understand the standard structure of health informatics.
C.	To learn the technicality associated with health informatics and design of basic telemetry technique.
D.	To understand the engineering aspects for patient data safety associated with hospital information system.

Course Outcomes

After the completion of this course, students will be:

1.	Understand the general architecture of hospital information system.
2.	Understand the fundamentals of the concept and design of clinical decision support system.
3.	Understand the importance of medical data and telemedicine for better healthcare.
4.	Analyse the data safety measures in hospital information system.
5.	Work in an interdisciplinary team.

Syllabus

Health Informatics and Telemedicine

Credits:3

Module-1: Medical data and records, coding, classification, database and reference models, data modeling, data control; Interfaces, data acquisition, processing and exchange standards; Patient centered information system; Clinical departmental systems; Clinical support system; Hospital and nursing information system; Implementations and evaluations. [8]

Module-2: Methods of decision support; Clinical decision support system; Medical knowledge acquisition; tools for clinical decision support. [8]

Module-3: Information technology in healthcare: Overview of telemedicine with its origin and development; Drivers of telemedicine and telecare; Types of telemedicine, benefits and limitations. [8]

Module-4: Technology in telemedicine: Information types and transmission in telemedicine, teleconsultation system components; Telecommunication options in healthcare, integration and operational issues; Wireless Technology in Patient Monitoring. [8]

Module-5: Development and delivery of telemedicine services: Technologies in Medical Information Processing; Data collection from patients, biosignal transmission and processing, patient records and data mining; Application of information technology in alternative medicine, physiotherapy and elderly people; Information technology for Caring for the Community. [8]

Text Books

1. Handbook of Medical Informatics, J. H. van Bemmel and M.A. Musen, Springer-Verlag
2. Essentials of Telemedicine and Telecare, by A. C. Norris, John Wiley and Sons
3. Telemedicine Technologies, Information Technologies in Medicine and Telehealth by Bernard Fong, A.C.M. Fong and C.K. Li, John Wiley and Sons, Ltd., Publication

Reference Books

1. Handbook of Telemedicine, by O. Ferrer-Roca and M. Sosa-Iudicissa, IOS Press
2. Health Communication, by R. K. Thomas, Springer
3. Healthcare informatics and information synthesis: developing and applying clinical knowledge to improve outcomes by J W Williamsons, Sage publications Inc

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

POs met through Gaps in the Syllabus

15. Conducting presentations in group and writing reports
16. Giving assignments to the students on some relevant topics
17. Industrial/Hospitals visits

POs met are: a, b, c, f

Topics beyond syllabus/Advanced topics/Design

10. Lecture on advancements in telemetry system
11. Lecture on technical components in remote surgery

POs met through Topics beyond syllabus/Advanced topics/Design

POs met are: f, g

Course Delivery methods
Lecture by use of boards/LCD projectors/OHP projectors (CD1)
Tutorials/Assignments (CD2)

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Mid Sem Examination Marks	25
Faculty Assessment	05
Assignment / Quiz (s) (2 No.)	20
End Sem Examination Marks	50

Assessment Compoents	CO1	CO2	CO3	CO4	CO5
Mid Sem Examination Marks	√	√	√	√	√
End Sem Examination Marks	√	√	√	√	√
Assignment	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	L
i		3		2				1				
ii	3	3	3	3						3		3
iii	3	3	3	3						3		3
iv	3	3				2	2					1
v					3		2		3		2	3

Mapping Between COs and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO2	CD5

COURSE INFORMATION SHEET

Course Code: BE415
Course title: Basic Biotechnology Lab
Pre-requisite(s): Nil
Co- requisite(s):
Credits: 1.5 L:0 T:0 P: 3
Class schedule per week: 3
Class: BTech
Semester / Level: VII/4
Branch: Minor in Biotechnology
Name of Teacher:

BE415 Basic Biotechnology Lab

1. Laboratory safety-general rules and regulations laboratory protocol
2. Sterilization techniques
3. Use of microscope
4. Identification of given plant, animal and bacterial cells and their components by microscopy
5. Simple staining
6. Gram's Staining
7. Identification of cells in a blood smear
8. Identification of blood group
9. Preparation of buffers and measurement of ph
10. Estimation of proteins by lowry's method / biuret method
11. Estimation of sugars
12. Acid hydrolysis and action of salivary amylase on starch
13. Culture Techniques, Isolation and Preservation of Cultures- Broth: flask, test tubes; Solid: Pour plates, streak plates, slants, stabs
14. Staining for different stages of mitosis in AlliumCepa (Onion)
15. Osmosis and Tonicity

Course Outcomes

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

1.	apply knowledge of biotechnology, inculcate a knowledge of various issues related to biotechnological techniques.
2.	design and conduct experiments, as well as to analyze and interpret data of different biotechnological methods.
3.	identify, formulate, and solve problems arisen due to the inefficient functioning of the systems in life sciences.
4.	use the techniques, skills, and modern tools necessary for detection of the presence of

	biomolecules and their estimation collection and analysis of data, and interpretion of results.
5.	demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work a recognition of the need for and an ability to engage in life-long learning

Credit: 1.5

S. No:	Name of Experiments	CO	PO
Experiment 1:	Laboratory safety-general rules and regulations laboratory protocol	1, 2, 5	a, b, c, j, k, l
Experiment 2:	Sterilization techniques	1, 2, 5	a, b, c, g, i, k, l
Experiment 3:	Use of microscope	1, 2, 5	a, b, e, j, k, l
Experiment 4:	Identification of given plant, animal and bacterial cells and their components by microscopy	1, 2, 3, 5	a, b, c, e, j, k, l
Experiment 5:	Simple staining	1, 2, 5	a, b, c, g, i, j, k, l
Experiment 6:	Gram's Staining	1, 2, 5	a, b, g, i, k, l
Experiment 7:	Identification of cells in a blood smear	1, 3, 5	a, b, c, e, f, l,
Experiment 8:	Identification of blood group	1, 2, 3, 5	a, b, c, e, f, l,
Experiment 9:	Preparation of buffers and measurement of ph	1, 2, 5	a, b, c, e, f, l,
Experiment 10:	Estimation of proteins by lowry's method / biuret method	1, 2, 3, 4, 5	a, b, c, e, f, l,
Experiment 11:	Estimation of sugars	1, 2, 3, 4, 5	a, b, c, d, h, l
Experiment 12:	Acid hydrolysis and action of salivary amylase on starch	1, 2, 3, 4, 5	a, b, c, d, h, l
Experiment 13:	Culture Techniques, Isolation and Preservation of Cultures- Broth: flask, test tubes; Solid: Pour plates, streak plates, slants, stabs	1, 2, 3, 5	a, b, c, d, h, l

Experiment 14:	Staining for different stages of mitosis in *Allium cepa* (Onion)	1, 2, 3, 5	a, b, c, e, f, l,
Experiment 15:	Osmosis and Tonicity	1, 2, 3, 5	a, b, c, e, f, l,

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

COURSE INFORMATION SHEET

Course Code: BE416
Course title: Process Biotechnology Lab
Pre-requisite(s):
Co- requisite(s):
Credits: 1.5 L:0 T:0 P: 3
Class schedule per week: 3
Class: BTech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Process Biotechnology Lab

List of Experiments

1. To study different parts of bioreactor and other accessories required during cultivation
2. To calibrate pH and DO sensors
3. To prepare standard plot of protein
4. To prepare standard plot of ammonia
5. To prepare standard plot of sugar
6. To monitor growth of provided bacteria and mass balance
7. Immobilization of whole cells by entrapment
8. To perform kinetic study of hydrolyzing enzyme

Lab Course Outcomes

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

1.	Gain knowledge of fermenter and fermentation processes
2.	To plot standard cures of related substrate and products and their role in different assay
3.	Find out behaviour of growth of organism in liquid medium
4.	Know the method and significance of immobilization
5.	Understand the different kinetic study like Km and Vmax of enzyme catalysis

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	L
1	3	3		3		2				2		1
2			3	3				2				1
3	3				2					2	1	1
4		3	3						2		1	1
5		3	3	3			2			2	1	1

COURSE INFORMATION SHEET

Course Code: BE417
Course title: Molecular modelling & Drug Design Lab
Pre-requisite(s): BE321 Cheminformatics, BE328 Molecular Simulation of Biomolecules
Co- requisite(s):
Credits: 1.5 L:0 T:0 P: 3
Class schedule per week: 3
Class: B. Tech
Semester / Level: VII/4
Branch: Biotechnology
Name of Teacher:

Credit: 1.5

Molecular modelling & Drug Design Lab

Experiment 1:	Designing new molecules with Chem-sketch/Chem-draw
Experiment 2:	Introduction to 'ZINC' and 'Drugbank' databases
Experiment 3:	Protein Structure Prediction Tools: Modeller
Experiment 4:	Molecular Modeling using Modeller (Local)/Swiss Modeller
Experiment 5:	Molecular Simulation using GROMACS
Experiment 6:	Ligand Designing and Molecular Docking: Autodock/ DS Modeller
Experiment 7:	Ligand Designing and Molecular Docking: DS Modeller
Experiment 8:	Molecular Simulation using DS Modeller
Experiment 9:	Trajectory analysis of molecules
Experiment 10:	Analysis of Protein-protein network

Books

1. **Andrew Leach:** Molecular Modelling: Principles and Applications
2. **Alan Hinchliffe**: Molecular Modelling for Beginners

Course Outcomes

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

1.	Apply knowledge of biotechnology, inculcate a knowledge of various issues related to Molecular modelling techniques. Evaluate the limitations of and troubleshoot theoretical approaches.
2.	Design and conduct experiments, as well as to analyze and interpret data of

	different modelling approaches.
3.	identify, formulate, and solve problems arisen due to the drug designing of the systems in life sciences.
4.	Use the techniques, skills, and modern tools necessary for detection of the validation of new drugs and biomolecules and its interaction and analysis of data, and interpretation of results.
5.	demonstrate knowledge and understanding of the engineering principles and apply these to manage projects work a recognition of the need for and an ability to engage in life-long learning
6.	Validation and compatibility of the structure of molecule in eukaryotic cells, prokaryotic cells and viruses.
7.	Independently execute an in-silico experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure Direct Assessment

Assessment Tool	% Contribution during CO Assessment
Continuous Internal Assessment 60% (Distribution is as follows)	60
a) Day to day performance & Lab files	30
b) Quiz (es)	10
c) Viva	20
Semester End Examination (Distribution is as follows)	40
a) Examination Experiment Performance	30
b) Quiz	10
Total	100

Indirect Assessment –

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

COURSE INFORMATION SHEET

Course Code: BE400
Course title: Research Project / Industry Internship
Pre-requisite(s):
Co- requisite(s):
Credits: 12 L:0 T:0 P: 3
Class schedule per week: 24-30 hours
Class: BTech
Semester / Level: VIII/4
Branch: Biotechnology
Name of Teacher: Respective Research Project / Industry Internship supervisors

Course Objectives

This course enables the students:

A.	To demonstrate a sound technical knowledge of their specific selected project topic. Able to impart knowledge for interdisciplinary, applied engineering and technology aspects.
B.	To execute problem identification, formulation and solution operations in order to conduct an engineering project.
C.	To design engineering solutions to complex problems utilising a systematic methodology.
D.	To communicate with engineers/biotechnologists and the community in a professional manner in written and oral forms.

Course Outcomes

After the completion of this course, students will be:

1.	Able to demonstrate a sound technical knowledge of their specific selected project topic specially in biotechnology. Able to correlate interdisciplinary/applied engineering and technology aspects of biotechnology.
2.	Able to collect data related to a societal and scientific issue in the area of biotechnology, analyse and interpret them.
3.	Able to identify the scientific problem, design engineering solutions for them by using a systematic approach.
4.	Able to communicate with engineers/biotechnologists and the community in a professional manner in written and oral forms. They will be able to write an engineering report on a biotechnological issue.

5.	Work in an interdisciplinary team.

Course Delivery methods	
Lecture by use of boards/LCD projectors/OHP projectors	
Tutorials/Assignments	
Seminars	**x**
Mini projects/Projects	x
Laboratory experiments/teaching aids	x
Industrial/guest lectures	
Industrial visits/in-plant training	x
Self- learning such as use of NPTEL materials and internets	x
Simulation	x

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment

Assessment Tool	% Contribution
a) External Examiner	50%
b) Project Guide	25%
c) DPEC	25%
TOTAL	**100%**

Assessment Components	CO1	CO2	CO3	CO4	CO5
DPEC	√	√	√	√	√
Project Guide	√	√	√	√	√
External Examiner	√	√	√	√	√

Indirect Assessment –

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

Mapping between Objectives and Outcomes

Course Outcome	Program Outcomes											
	a	b	c	d	e	f	g	h	i	j	k	l
1	3	3	3	2	3	1	1	1	1	3	1	
2	3	3	3	3	3	1	1	1	1	1	1	3
3	3	3	3	3	3	2	3	1	3	1	3	3
4	3	3	3	3	3	3	3	3	3	1	3	1
5	2					3	3	3	3	2	2	3

Mapping Between COs and Course Delivery (CD) methods

Mapping Between Cos and Course Delivery (CD) methods				
CD	**Course Delivery methods**		**Course Outcome**	**Course Delivery Method**
CD1	Lecture by use of boards/LCD projectors		CO1, CO2, CO3,CO4	CD1
CD2	Tutorials/Assignments		CO5	CD1 and CD2
CD5	Laboratory experiments/teaching aids		CO2	CD5