



Department of Bio-Engineering
BIRLA INSTITUTE OF TECHNOLOGY
MESRA-835215 (RANCHI) INDIA

Metric 1.1.3 and 1.2.1

Department/Section: Bio-Engineering Department

1.1.3 - Average percentage of courses having focus on employability/entrepreneurship/skill development during the last five years

1.2.1 - Percentage of new courses introduced of the total number of courses across all programmes offered during the last five years

Metric 1.1.3: Average percentage of courses having focus on employability/entrepreneurship/skill development during the last five years

Name of the Course introduced in last 5 years	Course Code	Year of introduction	Activities/Content with direct bearing on Employability/ Entrepreneurship/ Skill development	Program name	Program code
BE101-BIOLOGICAL SCIENCE FOR ENGINEERS	BE101	2018	Employability	B.E.(Biotechnology)	BE0102
BE203-MICROBIOLOGY	BE203	2018	Skill development	B.E.(Biotechnology)	BE0102
BE501-ADVANCED BIOPROCESS ENGINEERING	BE501	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE502 R-DNA TECH. & GENETIC ENGINEERING [M]	BE502	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE503-ADVANCED REACTION ENGINEERING	BE503	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE504-BIOPROCESS ENGINEERING LAB	BE504	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE505-R-DNA TECHNOLOGY LAB	BE505	2018	Skill development	M.TECH (Biotechnology)	MT0202

BE506 BIOPROCESS PLANT DESIGN	BE506	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE507-ADVANCED BIOSEPARATION ENGINEERING	BE507	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE508 BIOPHYSICS	BE508	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE509-BIOPROCESS PLANT DESIGN LAB	BE509	2018	Employability/Entrepreneurship	B.E.(Biotechnolog)	BE0102
BE510-BIOSEPARATION ENGINEERING LAB	BE510	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE511-ENVIRONMENTAL BIOTECHNOLOGY	BE511	2018	Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE512-MODERN METHODS OF INSTRUMENTATION	BE512	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE513-ANIMAL CELL CULTURE	BE513	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE514-CELL SIGNALING AND ELECTROPHYSIOLOGY	BE514	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE515-PROCESS BIOTECHNOLOGY	BE515	2018	Employability & Entrepreneurship	M.TECH (Biotechnology)	MT0202
BE516-STEM CELLS & TISSUE ENGINEERING	BE516	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE517-PROTEIN ENGINEERING	BE517	2018	Skill development	M.TECH (Biotechnology)	MT0202
BE518-BIOMEDICAL INSTRUMENTATION	BE518	2018	Skill development	M.TECH (Biotechnology)	MT0202
BT3023-CELL & MOLECULAR BIOLOGY	BT3023	2011	Skill development	B.E.(Biotechnolog)	BE0102
BT3025-BIO-ANALYTICAL TECHNIQUES	BT3025	2011	Entrepreneurship / Skill development	B.E.(Biotechnolog)	BE0102
BT3027-BIOMOLECULAR & BIOENERGETICS	BT3027	2011	Employability/Skill development	B.E.(Biotechnology)	BE0102
BT3029-CHEMICAL ENGINEERING-I	BT3029	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
BT401 MOLECULARCELL BIOLOGY [M]	BT401	2018	Employability/ Entrepreneurship	MSC (Biotechnology)	MS0102
BT402 METABOLISM AND BIOENERGETICS[M]	BT402	2018	Skill development	MSC (Biotechnology)	MS0102
BT4021-CHEMICAL ENGINEERING-II [M]	BT4021	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
BT4023-MICROBIOLOGY [M]	BT4023	2011	Skill development	B.E.(Biotechnology)	BE0102
BT4025-IMMUNOLOGY [M]	BT4025	2011	Employability/Skill	B.E.(Biotechnology)	BE0102

			development		
BT4027-THERM. OF CHEM. & BIOLOGICAL SYSTEMS [M]	BT4027	2011	Skill development	B.E.(Biotechnology)	BE0102
BT403 APPLIED MICROBIOLOGY [M]	BT403	2018	Skill development	MSC (Biotechnology)	MS0102
BT404 MATHEMATICS& STATISTICSFOR BIOLOGISTS [M]	BT404	2018	Skill development	MSC (Biotechnology)	MS0102
BT405-CELL BIOLOGY AND BIOCHEMISTRY LAB	BT405	2018	Skill development	MSC (Biotechnology)	MS0102
BT406-MICROBIOLOGY LAB	BT406	2018	Skill development	MSC (Biotechnology)	MS0102
BT407 GENOMICS[M]	BT407	2018	Skill development	MSC (Biotechnology)	MS0102
BT408-GENOMICSLAB	BT408	2018	Skill development	MSC (Biotechnology)	MS0102
BT409-INDUSTRIAL BIOTECHNOLOGY	BT409	2018	Employability & Entrepreneurship	MSC (Biotechnology)	MS0102
BT410-INDUSTRIAL BIOTECHNOLOGY LAB	BT410	2018	Employability & Entrepreneurship	MSC (Biotechnology)	MS0102
BT411- MOLECULARPLANT PHYSIOLOGY	BT411	2018	Skill development	MSC (Biotechnology)	MS0102
BT412- MOLECULARPLANT PHYSIOLOGY LAB	BT412	2018	Skill development	MSC (Biotechnology)	MS0102
BT413-BIOSIGNAL ACQUISITION SYSTEM	BT413	2018	Skill development	MSC (Biotechnology)	MS0102
BT414-BIOSIGNAL ACQUISITION SYSTEM LAB	BT414	2018	Skill development	MSC (Biotechnology)	MS0102
BT415- MOLECULARBIOLOGY & RECOMBINANT DNA TECHNOLOGY	BT415	2018	Skill development	MSC (Biotechnology)	MS0102
BT416-ENZYMEAND BIOPROCESS TECHNOLOGY	BT416	2018	Employability & Entrepreneurship	MSC (Biotechnology)	MS0102
BT418-ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY	BT418	2018	Skill development	MSC (Biotechnology)	MS0102
BT419-ENZYMEAND BIOPROCESS TECHNOLOGY LAB	BT419	2018	Employability & Entrepreneurship	MSC (Biotechnology)	MS0102
BT420-GENOMICSAND R-DNA TECHNOLOGY LAB	BT420	2018	Skill development	MSC (Biotechnology)	MS0102
BT421-PROTEOMICS	BT421	2018	Skill development	MSC (Biotechnology)	MS0102

BT422-PROTEOMICSLAB	BT422	2018	Skill development	MSC (Biotechnology)	MS0102
BT423-ANIMAL BIOTECHNOLOGY	BT423	2018	Skill development	MSC (Biotechnology)	MS0102
BT424-ANIMAL CELL TECHNOLOGY LAB	BT424	2018	Skill development	MSC (Biotechnology)	MS0102
BT425-PLANT BIOTECHNOLOGY	BT425	2018	Skill development	MSC (Biotechnology)	MS0102
BT426-PLANT BIOTECHNOLOGY LAB	BT426	2018	Skill development	MSC (Biotechnology)	MS0102
BT427-BIOMEDICAL INSTRUMENTATION	BT427	2018	Skill development	MSC (Biotechnology)	MS0102
BT428-BIOMEDICAL INSTRUMENTATION LAB	BT428	2018	Skill development	MSC (Biotechnology)	MS0102
BT429-CONCEPTS IN NANOBIO TECHNOLOGY	BT429	2018	Skill development	MSC (Biotechnology)	MS0102
BT430-BASIC NANOBIO TECHNOLOGY LAB	BT430	2018	Skill development	MSC (Biotechnology)	MS0102
BT5021-BIOPROCESS ENGINEERING	BT5021	2011	Employability/ Entrepreneurship	B.E.(Biotechnology)	BE0102
BT5023-CHEMICAL ENGINEERING-III	BT5023	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
BT5025-FUNCTIONAL GENOMICS AND RDNA TECHNOLOGY	BT5025	2011	Employability/ Skill development	B.E.(Biotechnology)	BE0102
BT5027-REACTION ENGINEERING	BT5027	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
BT6021-BIOSEPARATION ENGINEERING [M]	BT6021	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
BT6023-PLANT & AGRICULTURE BIOTECHNOLOGY [M]	BT6023	2011	Employability/Ent repreneurship	B.E.(Biotechnology)	BE0102
BT6025-FOOD & ENZYME TECHNOLOGY [M]	BT6025	2011	Employability/ Entrepreneurship	B.E.(Biotechnology)	BE0102
BT6027-PROCESS MEASUREMENT & CONTROL [M]	BT6027	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
BT7021-BIOLOGICAL WASTE MGT.	BT7021	2011	Employability	B.E.(Biotechnology)	BE0102
BT7023 BIOREACTOR AND BIOPROCESS DESIGN	BT7023	2011	Employability/ Entrepreneurship / Skill development	B.E.(Biotechnology)	BE0102
BT7035 IPR, BIOSAFETY & BIOETHICS	BT7035	2011	Employability/ Entrepreneurship	B.E.(Biotechnology)	BE0102
BT8021 BIOTECHNOLOGY MANAGEMENT [M]	BT8021	2011	Entrepreneurship	B.E.(Biotechnology)	BE0102
MCA2005 DATABASE	MCA2005	2010	Skill	MSC (Bio-	MS0202

MGT. SYSTEM [MKNALJ]			development	Informatics)	
MEE2115 EMBEDDED SYSTEM & APPLICATION	MEE2115	2013	Employability	M.TECH (Biomedical Instrumentation)	MT0202
MPS1101 ADVANCED INSTRUMENTAL ANALYSIS	MPS1101	2013	Skill development	M.TECH (Biomedical Instrumentation)	MT0202
SBI3001 GENOMICS & BIO-SEQUENCE ANALYSIS	SBI3001	2010	Employability/Skill development	MSC (Bio-Informatics)	MS0202
SBI3003 MOLECULAR MODELING & DRUG DESIGN	SBI3003	2010	Skill development	MSC (Bio-Informatics)	MS0202
SBI3005 PERL PROGRAMMING & WEB TECH.	SBI3005	2010	Employability/Skill development	MSC (Bio-Informatics)	MS0202
SBI3011 GENETIC ENGINEERING	SBI3011	2010	Skill development	MSC (Bio-Informatics)	MS0202
SBT1001 CELL BIOLOGY & MOLECULAR GENETICS	SBT1001	2014	Skill development	MSC (Biotechnology)	MS0102
SBT1003 BIOCHEMISTRY	SBT1003	2014	Employability	MSC (Biotechnology)	MS0102
SBT1005 MICROBIOLOGY	SBT1005	2014	Employability	MSC (Biotechnology)	MS0102
SBT1007 MATHEMATICS FOR BIOLOGISTS	SBT1007	2014	Skill development	MSC (Biotechnology)	MS0102
SBT2001 ENZYME TECHNOLOGY	SBT2001	2014	Entrepreneurship / Skill development	MSC (Biotechnology)	MS0102
SBT2003 MOLECULAR BIOLOGY & RDNA TECHNOLOGY	SBT2003	2014	Employability/Skill development	MSC (Biotechnology)	MS0102
SBT2005 BIOPROCESS TECHNOLOGY	SBT2005	2014	Employability/Entrepreneurship	MSC (Biotechnology)	MS0102
SBT2007 BIOINFORMATICS	SBT2007	2014	Skill development	MSC (Biotechnology)	MS0102
TBT NC21 BIOENTERPRENURSHIP [MK]	TBTNC21	2010	Entrepreneurship	M.TECH (Biotechnology)	MT0102
TBT1001 BIOPROCESS ENGINEERING [MK]	TBT1001	2010	Employability/Entrepreneurship	M.TECH (Biotechnology)	MT0102
TBT1003 R-DNA TECHNOLOGY & GENETIC ENGG. [MK]	TBT1003	2010	Entrepreneurship / Skill development	M.TECH (Biotechnology)	MT0102
TBT1005 BIOPHYSICS [MK]	TBT1005	2010	Skill development	M.TECH (Biotechnology)	MT0102
TBT1011 ANIMAL BIOTECHNOLOGY	TBT1011	2010	Employability/Skill development	M.TECH (Biotechnology)	MT0102

TBT1015 PHARMACEUTICAL BIOTECHNOLOGY	TBT1015	2010	Employability/ Entrepreneurship	M.TECH (Biotechnology)	MT0102
TBT2001 BIOPROCESS PLANT DESIGN [MK]	TBT2001	2010	Employability/ Entrepreneurship	M.TECH (Biotechnology)	MT0102
TBT2003 DOWNSTREAM PROCESSING [MK]	TBT2003	2010	Entrepreneurship	M.TECH (Biotechnology)	MT0102
TBT2005 IPR BIOSAFETY & BIOETHICS [MK]	TBT2005	2010	Entrepreneurship	M.TECH (Biotechnology)	MT0102
TBT2011 IMMUNOTECHNOLOGY [MK]	TBT2011	2010	Entrepreneurship / Skill development	M.TECH (Biotechnology)	MT0102
TBT2021 COMPUTATIONAL BIOLOGY	TBT2021	2010	Skill development	M.TECH (Biotechnology)	MT0102
TBT2023 ENVIRONMENTAL BIOTECHNOLOGY	TBT2023	2010	Employability/Ski ll development	M.TECH (Biotechnology)	MT0102
TBTNC1 BIOSTATISTICS	TBTNC1	2010	Skill development	M.TECH (Biotechnology)	MT0102
TCS1021 DATA STRUCTURE & ALGO. DESIGN	TCS1021	2010	Skill development	MSC (Bio- Informatics)	MS0202
TES2017 WASTE MANAGEMENT	TES2017	2010	Entrepreneurship	M.TECH (Biotechnology)	MT0102
TMI1001 BIOINSTRUMENTATION & MEASUREMENT	TMI1001	2013	Employability/ Entrepreneurship	M.TECH (Biomedical Instrumentation)	MT0202
TMI1005 HEALTH INFORMATICS & TELEMEDICINE	TMI1005	2013	Skill development	M.TECH (Biomedical Instrumentation)	MT0202
TMI1023 ANATOMY & PHYSIOL. FOR BIOMEDICAL ENGINEERS	TMI1023	2013	Skill development	M.TECH (Biomedical Instrumentation)	MT0202
TMI2001 BIOMECHANICS & HUMAN FACTORS ENGINEERING	TMI2001	2013	Entrepreneurship	M.TECH (Biomedical Instrumentation)	MT0202
TMI2003 MEDICAL IMAGING SYSTEMS	TMI2003	2013	Employability/ Entrepreneurship	M.TECH (Biomedical Instrumentation)	MT0202
TMI2007 PHSIOLOGICAL CONTROL SYSTEMS	TMI2007	2013	Skill development	M.TECH (Biomedical Instrumentation)	MT0202
TNT1001 INTRO. TO NANOSCIENCE & NANOTECHNOLOGY	TNT1001	2013	Skill development	M.TECH (Biomedical Instrumentation)	MT0202
TPT1021 PRINCIPLES OF POLYMER TECHNOLOGY	TPT1021	2010	Employability	M.TECH (Biotechnology)	MT0102



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Metric 1.2.1

Department/Section: Bio-Engineering Department

Metric 1.2.1: Percentage of new courses introduced of the total number of courses across all programmes offered during the last five years

Name of the new course introduced in the last 5 years	Course code	Year of introduction	Employability/ Entrepreneurship/ Skill development	Program name	Program code
Advanced Bioprocess Engineering	BE 501	2018	Employability & Entrepreneurship	M.Tech. (Biotechnology)	MT0102
Advanced Bioseparation Engineering	BE 507	2018	Employability & Entrepreneurship	M.Tech. (Biotechnology)	MT0102
Advanced Reaction Engineering	BE 503	2018	Employability & Entrepreneurship	M.Tech. (Biotechnology)	MT0102
Analytical Techniques in Biotechnology	BT 418	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Animal Biotechnology	BT423	2018	Skill development	M. Sc. (Biotechnology)	MS0102
Animal Cell Culture	BE 513	2018	Skill development	M.Tech. (Biotechnology)	MT0102
Animal cell Technology lab	BT424	2018	Skill development	M. Sc. (Biotechnology)	MS0102
Applied Microbiology	BT403	2018	Employability & Entrepreneurship	M.Sc. (Biotechnology)	MS0102
Basic Nanobiotechnology lab	BT430	2018	Skill development & Employability	M.Sc. (Biotechnology)	MS0102
Bioinformatics	BT 417	2018	Skill development	M. Sc. (Biotechnology)	MS0102
Biomedical equipments and device	BT427	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Biomedical Instrumentation	BE 518	2018	Skill development	M.Tech. (Biotechnology)	MT0102

Biomedical Instrumentation	BT427	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Biomedical Instrumentation Lab	BT428	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Biomedical Instrumentation Lab	BT430	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Biophysics	BE508	2018		M. Tech. (Biotechnology)	MT0102
Bioprocess Engineering Lab	BE504	2018	Employability & Entrepreneurship	M.Tech. (Biotechnology)	MT0102
Bioprocess Engineering Lab	BE504	2018	Employability & Entrepreneurship	M. Tech. (Biotechnology)	MT0102
Bioprocess Plant Design	BE506	2018	Employability & Entrepreneurship	M. Tech. (Biotechnology)	MT0102
Bioprocess Plant Design Lab	BE509	2018	Employability & Entrepreneurship	M. Tech. (Biotechnology)	MT0102
Bioseparation Engineering Lab	BE510	2018	Employability & Entrepreneurship	M.Tech. (Biotechnology)	MT0102
Biosignal Acquisition System	BT413	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Biosignal Acquisition System Lab	BT414	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Cell Biology and Biochemistry Lab	BT405	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Cell signaling and Electrophysiology	BE 514	2018	Skill development	M.Tech. (Biotechnology)	MT0102
Concepts in Nanobiotechnology	BT429	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Environmental Biotechnology	BE511	2018	Skill development	M. Tech. (Biotechnology)	MT0102
Enzyme and Bioprocess Technology	BT 416	2018	Skill development & Employability	M.Sc. (Biotechnology)	MS0102
Enzyme and Bioprocess Technology Lab	BT419	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Genomics	BT407	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Genomics and r-DNA Technology Lab	BT420	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Genomics Lab	BT408	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Industrial Biotechnology	BT409	2018	Skill development &	M. Sc.	MS0102

			Employability	(Biotechnology)	
Industrial Biotechnology Lab	BT410	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Mathematics and Statistics for BIOLOGIST	BT404	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Metabolism and Bioenergetics	BT402	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Microbiology Lab	BT406	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Modern Methods of Instrumentation	BE 512	2018	Skill development	M.Tech. (Biotechnology)	MT0102
Modern Methods of Instrumentation	BE 512	2018	Skill development & Employability	M. Tech. (Biotechnology)	MT0102
Molecular biology & Recombinant DNA Technology	BT415	2018	Skill development & Employability	M. Sc. (Biotechnology)	MS0102
Molecular Cell Biology	BT401	2018	Employability & Entrepreneurship	M.Sc. (Biotechnology)	MS0102
Molecular Plant Physiology	BT 411	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Molecular Plant Physiology Lab	BT412	2018	Skill development	M.Sc. (Biotechnology)	MS0102
Plant Biotechnology	BT425	2018	Molecular biology & Recombinant DNA Technology	M. Sc. (Biotechnology)	MS0102
Plant Biotechnology lab	BT426	2018	Molecular biology & Recombinant DNA Technology	M. Sc. (Biotechnology)	MS0102
Process Biotechnology	BE 515	2018	Employability & Entrepreneurship	M.Tech. (Biotechnology)	MT0102
Protein Engineering	BE517	2018	Molecular biology & Recombinant DNA Technology	M. Tech. (Biotechnology)	MT0102
Proteomics	BT421	2018	Molecular biology & Recombinant DNA Technology	M. Sc. (Biotechnology)	MS0102
Proteomics lab	BT422	2018	Molecular biology & Recombinant DNA Technology	M. Sc. (Biotechnology)	MS0102
r-DNA Tech. & Genetic Engineering	BE 502	2018	Molecular biology & Recombinant DNA Technology	M. Tech. (Biotechnology)	MT0102

r-DNA Technology Lab	BE505	2018	Molecular biology & Recombinant DNA Technology	M. Tech. (Biotechnology)	MT0102
Stem Cells & Tissue Engineering	BE 516	2018	Skill development and Employability	M.Tech. (Biotechnology)	MT0102

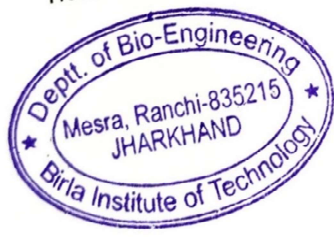

 Head of Department


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12	Animal Biotechnology	BT423	M. Sc. (Biotechnology)	256
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			(Biotechnology)	
15	Applied Microbiology	BT403	M.Sc. (Biotechnology)	199
16	Basic Nanobiotechnology lab	BT430	M.Sc. (Biotechnology)	277
17	Bioinformatics	BT 417	M. Sc. (Biotechnology)	238
18	Biomedical equipments and device	BT427	M. Sc. (Biotechnology)	268
19	Biomedical Instrumentation	BE 518	M.Tech. (Biotechnology)	88
20	Biomedical Instrumentation Lab	BT428	M.Sc. (Biotechnology)	271
21	Biophysics	BE508	M. Tech. (Biotechnology)	49
22	Bioprocess Engineering Lab	BE504	M.Tech. (Biotechnology)	35
23	Bioprocess Plant Design	BE506	M. Tech. (Biotechnology)	41
24	Bioprocess Plant Design Lab	BE509	M. Tech. (Biotechnology)	53
25	Bioseparation Engineering Lab	BE510	M.Tech. (Biotechnology)	56
26	Biosignal Acquisition System Lab	BT414	M.Sc. (Biotechnology)	229
27	Cell Biology and Biochemistry Lab	BT405	M.Sc. (Biotechnology)	205
28	Cell signaling and Electrophysiology	BE 514	M.Tech. (Biotechnology)	72
29	Concepts in Nanobiotechnology	BT429	M.Sc. (Biotechnology)	274
30	Environmental Biotechnology	BE511	M. Tech. (Biotechnology)	60
31	Enzyme and Bioprocess Technology	BT 416	M.Sc. (Biotechnology)	235
32	Enzyme and Bioprocess Technology Lab	BT419	M. Sc. (Biotechnology)	244

33	Genomics	BT407	M.Sc. (Biotechnology)	211
34	Genomics and r-DNA Technology Lab	BT420	M. Sc. (Biotechnology)	247
35	Genomics Lab	BT408	M.Sc. (Biotechnology)	214
36	Industrial Biotechnology	BT409	M. Sc. (Biotechnology)	217
37	Industrial Biotechnology Lab	BT410	M. Sc. (Biotechnology)	220
38	Mathematics and Statistics for BIOLOGIST	BT404	M.Sc. (Biotechnology)	202
39	Metabolism and Bioenergetics	BT402	M.Sc. (Biotechnology)	196
40	Microbiology Lab	BT406	M. Sc. (Biotechnology)	208
41	Modern Methods of Instrumentation	BE 512	M.Tech. (Biotechnology)	64
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43	Molecular Cell Biology	BT401	M.Sc. (Biotechnology)	193
44	Molecular Plant Physiology	BT 411	M.Sc. (Biotechnology)	223
45	Molecular Plant Physiology Lab	BT412	M.Sc. (Biotechnology)	226
46	Plant Biotechnology	BT425	M. Sc. (Biotechnology)	262
47	Plant Biotechnology lab	BT426	M. Sc. (Biotechnology)	265
48	Process Biotechnology	BE 515	M.Tech. (Biotechnology)	76
49	Protein Engineering	BE517	M. Tech. (Biotechnology)	84
50	Proteomics	BT421	M. Sc. (Biotechnology)	250
51	Proteomics lab	BT422	M. Sc. (Biotechnology)	253
52	r-DNA Tech. & Genetic Engineering	BE 502	M. Tech. (Biotechnology)	27

53	r-DNA Technology Lab	BE505	M. Tech. (Biotechnology)	38
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Head of Department





Department of Bio-Engineering
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MESRA-835215 (RANCHI) INDIA

Ref: BT/BOS/18-19/03

Date: 27.04.2018

NOTICE

There will be a meeting of the Board of Studies of the Department of Bio-Engineering at **11.00 AM** in the office of the undersigned on **April 30, 2018** for the approval of CBCS based Course Curriculum of M. Tech (Biotechnology).

All the members are requested to make it convenient to attend the meeting.

1. Dr. Ramesh Chandra	Head & Chairman
2. Dr. T. R. Sharma	External Expert
3. Dr. Sudipta Goswami	Member
4. Dr. S. Samanta	Member
5. Dr. Kunal Mukhopadhyay	Member
6. Dr. Rakesh Kumar Sinha	Member
7. Dr. Padmini Padmanabhan	Member
8. Dr. Vinod Kumar Nigam	Member
9. Dr. Raju Poddar	Member


(Dr. Ramesh Chandra)
Head & Chairman



Department of Bio-Engineering
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MESRA-835215 (RANCHI) INDIA

Ref: BT/BOS/Min./18-19/02

Date: 30.04.2018

Minutes of Board of Studies Meeting

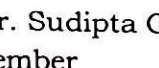
A meeting of Board of Studies of the Department of Bio-Engineering was held on 30.04.2018 at 11.00 AM to approve the CBCS based Course Curriculum of M. Tech Biotechnology.

Following members were present in the meeting and after discussion during the presentation of CBCS structure and syllabi, the following suggestions have been incorporated. Further, the committee forwards the same for the approval.

1. Dr. Ramesh Chandra	Chairman (Ex-Officio)
2. Dr. T. R. Sharma	External Expert
3. Dr. Sudipta Goswami	Member
4. Dr. S. Samanta	Member
5. Dr. Kunal Mukhopadhyay	Member
6. Dr. Rakesh Kumar Sinha	Member
7. Dr. Padmini Padmanabhan	Member
8. Dr. Vinod Kumar Nigam	Member
9. Dr. Raju Poddar	Member

- Pre-requisites and co-requisites should be provided for each subject.
- "Bioprocess Engineering" will be renamed as "Advanced Bioprocess Engineering".
- "Downstream processing" will also be renamed as "Advanced Bioseparation Engineering".
- "Reaction Engineering" will also be renamed as "Advanced Reaction Engineering" and will offered as Program Core (PC).
- The subject "Environmental Biotechnology" will be offered as Program Elective (PE).


[Dr. T. R. Sharma]
External Expert


[Dr. Sudipta Goswami]
Member


[Dr. S. Samanta]
Member


[Dr. Kunal Mukhopadhyay]
Member


[Dr. Rakesh Kr. Sinha]
Member


[Dr. P. Padmanabhan]
Member


[Dr. Vinod Kr. Nigam]
Member


[Dr. Raju Poddar]
Member


[Dr. Ramesh Chandra]
Chairman (Ex-Officio)



Department of Bio-Engineering
BIRLA INSTITUTE OF TECHNOLOGY
MESRA-835215 (RANCHI) INDIA

Ref: BT/BOS/18-19/02

Date: 27.04.2018

NOTICE

There will be a meeting of the Board of Studies of the Department of Bio-Engineering at **10.00 AM** in the office of the undersigned on **April 30, 2018** for the approval of CBCS based Course Curriculum of B. Tech (Biotechnology).

All the members are requested to make it convenient to attend the meeting.

1. Dr. Ramesh Chandra	Head & Chairman
2. Dr. T. R. Sharma	External Expert
3. Dr. Sudipta Goswami	Member
4. Dr. S. Samanta	Member
5. Dr. Kunal Mukhopadhyay	Member
6. Dr. Rakesh Kumar Sinha	Member
7. Dr. Padmini Padmanabhan	Member
8. Dr. Vinod Kumar Nigam	Member
9. Dr. Raju Poddar	Member


(Dr. Ramesh Chandra)
Head & Chairman
27/04/2018



Department of Bio-Engineering
BIRLA INSTITUTE OF TECHNOLOGY
MESRA-835215 (RANCHI) INDIA

Ref: BT/BOS/Min./18-19/01

Date: 30.04.2018

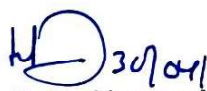
Minutes of Board of Studies Meeting

A meeting of Board of Studies of the Department of Bio-Engineering was held on 30.04.2018 at 10.00 AM to approve the CBCS based Course Curriculum of B. Tech Biotechnology.

Following members were present in the meeting and after discussion during the presentation of CBCS structure and syllabi, the following suggestions have been incorporated. Further, the committee forwards the same for the approval.

1. Dr. Ramesh Chandra	Chairman (Ex-Officio)
2. Dr. T. R. Sharma	External Expert
3. Dr. Sudipta Goswami	Member
4. Dr. S. Samanta	Member
5. Dr. Kunal Mukhopadhyay	Member
6. Dr. Rakesh Kumar Sinha	Member
7. Dr. Padmini Padmanabhan	Member
8. Dr. Vinod Kumar Nigam	Member
9. Dr. Raju Poddar	Member

- Pre- requisites and co-requisites should be provided for each subject.
- The "Biochemistry" under program core (PC) should be renamed as "Biochemistry & Enzyme Technology" including the content of "Enzyme Technology" offered under Program elective (PE).
- Listing of Programme electives level-wise.
- Reshuffling of the subjects as per Pre- requisites and co-requisites (eg. Reaction Engineering, Bioprocess Engineering)
- There should four-digit numeric code in place of three digits. The second digit of this system will be for representation of the number of revision of the syllabus.
- The code BE should be used for Engineering programs and BT for Science program.


[Dr. T. R. Sharma]
External Expert


[Dr. Sudipta Goswami]
Member


[Dr. S. Samanta]
Member


[Dr. Kunal Mukhopadhyay]
Member


[Dr. Rakesh Kr. Sinha]
Member


[Dr. P. Padmanabhan]
Member


[Dr. Vinod Kr. Nigam]
Member


[Dr. Raju Poddar]
Member


[Dr. Ramesh Chandra]
Chairman (Ex-Officio)



Department of Bio-Engineering
BIRLA INSTITUTE OF TECHNOLOGY
MESRA-835215 (RANCHI) INDIA

Ref: BT/BOS/18-19/04

Date: 27.04.2018

NOTICE

There will be a meeting of the Board of Studies of the Department of Bio-Engineering at **12.00 Noon** in the office of the undersigned on **April 30, 2018** for the approval of CBCS based Course Curriculum of M.Sc. (Biotechnology).

All the members are requested to make it convenient to attend the meeting.

1. Dr. Ramesh Chandra	Head & Chairman
2. Dr. T. R. Sharma	External Expert
3. Dr. Sudipta Goswami	Member
4. Dr. S. Samanta	Member
5. Dr. Kunal Mukhopadhyay	Member
6. Dr. Rakesh Kumar Sinha	Member
7. Dr. Padmini Padmanabhan	Member
8. Dr. Vinod Kumar Nigam	Member
9. Dr. Raju Poddar	Member


(Dr. Ramesh Chandra)
Head & Chairman



Department of Bio-Engineering
BIRLA INSTITUTE OF TECHNOLOGY
MESRA-835215 (RANCHI) INDIA

Ref: BT/BOS/Min./18-19/03

Date: 30.04.2018

Minutes of Board of Studies Meeting

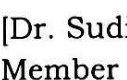
A meeting of Board of Studies of the Department of Bio-Engineering was held on 30.04.2018 at 12.00 noon to approve the CBCS based Course Curriculum of M. Sc. Biotechnology.

Following members were present in the meeting and after discussion during the presentation of CBCS structure and syllabi, the following suggestions have been incorporated. Further, the committee forwards the same for the approval.

1. Dr. Ramesh Chandra	Chairman (Ex-Officio)
2. Dr. T. R. Sharma	External Expert
3. Dr. Sudipta Goswami	Member
4. Dr. S. Samanta	Member
5. Dr. Kunal Mukhopadhyay	Member
6. Dr. Rakesh Kumar Sinha	Member
7. Dr. Padmini Padmanabhan	Member
8. Dr. Vinod Kumar Nigam	Member
9. Dr. Raju Poddar	Member

- Pre-requisites and co-requisites should be provided for each subject.
- There should four-digit numeric code in place of three digits. The second digit of this system will be for representation of the number of revision of the syllabus.
- The code BE should be used for Engineering programs and BT for Science program.


[Dr. T. R. Sharma]
External Expert


[Dr. Sudipta Goswami]
Member

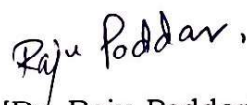

[Dr. S. Samanta]
Member

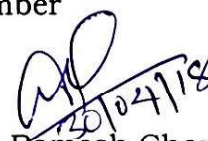

[Dr. Kunal Mukhopadhyay]
Member


[Dr. Rakesh Kr. Sinha]
Member


[Dr. P. Padmanabhan]
Member


[Dr. Vinod Kr. Nigam]
Member


[Dr. Raju Poddar]
Member


[Dr. Ramesh Chandra]
Chairman (Ex-Officio)



Department of Bio-Engineering

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

Institute Vision

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

Institute Mission

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

Department Vision

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

Department Mission

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

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

PEO 1: Students will acquire necessary knowledge and skills in the frontier areas of Biotechnology.

PEO 2: Students will think critically and creatively about the use of biotechnology to address local and global problems.

PEO 3: Students will be able to implement the engineering principles to biological systems for development of industrial applications, as well as entrepreneurship skills to start biotech industries.

PROGRAM OUTCOMES (POs) M.Tech in Biotechnology

PO1: An ability to independently carry out research /investigation and development work to solve practical problems.

PO2: An ability to write and present a substantial technical report/document.

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

PO4: Recognise the need for continuous learning and will prepare oneself to create, select, learn and apply appropriate techniques, resources, and modern instrumentation to solve complex biotechnological activities with an understanding of the limitations.

PO5: Demonstrate knowledge of biotechnology and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.

PO6: Possess scientific or technological knowledge in one or more domains of Biotechnology and recognize opportunities and contribute to collaborative-multidisciplinary research, demonstrate a capacity for teamwork, decision-making based on open-mindedness and rational analysis in order to achieve common goals.

COURSE INFORMATION SHEET

Course code: BE501

Course title: Advanced Bioprocess Engineering

Pre-requisite(s): B.E. /B. Tech./M.Sc. in Biotechnology/Life Sciences

Co- requisite(s): None

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

Class schedule per week: 03

Class: M. Tech.

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

	systems, solve calculation based on process economy as well as to recognize the importance of flow sheet of the production system.

SYLLABUS

Module I:

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

Module II:

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

Module III:

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

Module IV:

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

Module V:

Industrial Processes and Process Economics: Description of industrial processes for biochemicals production, Process flow sheeting and Process economics. (8L)

Text Books

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

Reference Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Design of real-time industrial projects.

POs met through Gaps in the Syllabus: PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects.

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE 502

Course title: Recombinant DNA Technology and Genetic Engineering

Pre-requisite(s): Knowledge on Molecular Biology and Biochemistry

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module I:

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

(8L)

Module II:

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

(8L)

Module III:

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

(8L)

Module IV:

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

(8L)

Module V:

Applications of Genetic Engineering: Gene therapy, Gene replacement & Suicide gene therapy, DNA vaccine, Terminator technology, Golden rice, Safety guidelines of recombinant DNA research.

(8L)

Text Books

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

3. Brown TA, Genomes, 3rd ed. Garland Science 2006

Reference Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE****Direct Assessment**

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE503

Course title: Advanced Reaction Engineering

Pre-requisite(s): Knowledge of Reaction engineering at UG level

Co- requisite(s): NIL

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course envisions imparting to students to:

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

Course Outcomes

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

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

SYLLABUS

MODULE I:

Introduction to Heterogeneous Reactions: Examples of heterogeneous reactions, Uncatalysed heterogeneous systems, Contacting pattern for two phase system, Kinetics of uncatalysed heterogeneous reactions, Problems.
(9L)

MODULE – II:

Introduction to Catalyst and Catalytic Reactors: Types of Catalysts Characterizations, Physical properties of catalyst, surface area, void volume, solid density, pore volume distribution, Classification and preparation of catalysts, catalyst promoters, Catalyst inhibitors, Catalyst poisons, Nature and Mechanism of catalytic reactions, Catalysts Deactivation and Regeneration, Packed bed reactor, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors etc., Problems.
(9L)

MODULE – III:

Solid Catalyzed Reactions: Introduction and Spectrum of kinetic regimes, Surface kinetics and rate equation, pore diffusion, porous catalyst, Heat effects, Performance Equation, Experimental methods and rate equation, Differential, integral, mixed batch and recycle reactors, determination of reactor size from rate equations.
(9L)

MODULE – IV:

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

MODULE – V:

Heterogeneous Reactions in Bioprocessing: General Discussions on Heterogeneous Reactions in Bioprocessing, Concentration Gradients and Reaction Rates in Solid Catalysts, Internal Mass Transfer and Reaction, The Thiele Modulus and Effectiveness Factor, External Mass Transfer, Liquid–Solid Mass Transfer Correlations, Experimental Aspects, Minimising Mass Transfer Effects, Evaluating True Kinetic Parameters. Problems.
(10L)

Text books:

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

Reference books:

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

2008.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

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

POs met through Gaps in the Syllabus: PO4 & PO5

Topics beyond syllabus/Advanced topics/Design:

Biochemical catalysis

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE504

Course title: Bioprocess Engineering Lab

Pre-requisite(s):

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

Credits: 2 L:0 T:0 P:4

Class schedule per week: 4

Class: M.Tech.

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

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

Experiments

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

Text Books

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

Reference Books

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

Course Evaluation:

Individual Laboratory experiments, Quiz and Progressive and End semester examinations

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

Design of real-time industrial projects.

POs met through Gaps in the Syllabus: PO5 & PO6

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects.

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE 505

Course title: Recombinant DNA Technology Lab

Pre-requisite(s): Knowledge on Molecular Biology and Biochemistry

Co- requisite(s): Recombinant DNA Technology and Genetic Engineering (BE502)

Credits: 2 L: 0 T: 0 P: 4

Class schedule per week: 04

Class: M. Tech

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Experiments:

1. Isolation of genomic DNA from plant leaves
2. Agarose gel electrophoresis of isolated genomic DNA
3. Isolation of total cellular RNA from plant leaves
4. Formaldehyde-agarose denaturing gel electrophoresis of RNA
5. Isolation of plasmid DNA from bacterial cultures and visualization on agarose gels
6. Spectrophotometric quantification and quality determination of isolated nucleic acids
7. Polymerase Chain Reaction based amplification of DNA
8. Real Time PCR based gene expression
9. Elution of DNA band from agarose gels
10. Ligation of eluted DNA to plasmid vectors for T/A based cloning
11. Preparation of culture media for transformation

12. Preparation of competent DH5 α cells for transformation
13. Transformation of competent cells and plating
14. Selection of transformants based on blue-white colonies and evaluation of plasmids from transformed colonies

Books recommended:

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

Course Evaluation:

Quiz and End semester laboratory-based examinations

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE 506

Course title: Bioprocess Plant Design

Pre-requisite(s): Nil

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

Syllabus

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

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

Module-3: Design of Vessels for Biotechnology Application: Design of Upstream and Down Stream process equipments; fermenters, design considerations for maintaining sterility of process streams processing equipment; Selection and specification of equipment for handling fluids and solids; Selection and basic concepts of design of heat exchangers used in bioprocess industries. (8L)

Module-4: Hazards and Safety: Design of facilities for cleaning of process equipment used in biochemical industries; Plant safety - the hazards procedures to overcome associated equipment design and operation; procedures to overcome hazards from safety point of views, Plant start-up safety review, safety aspects of the plant shut down procedures. Gantt chart (time schedule) with each steps of standard procedure of shut down of the plant. (8L)

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

Text Books:

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

Reference Books:

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

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Topics beyond syllabus/Advanced topics/Design: Nil

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE 507

Course title: Advanced Bioseparation Engineering

**Pre-requisite(s): BE501 Advanced Bioprocess Engineering,
BE 503 Advanced Reaction Engineering**

Co- requisite(s): BE506 Bioprocess Plant Design

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

Class schedule per week: 3

Class: M. Tech

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

CO5.	Perform crystallization and drying of a bio-molecule

SYLLABUS

MODULE-1: REMOVAL OF INSOLUBLE MATERIALS

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

MODULE-2: ISOLATION OF BIOMOLECULES

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

MODULE-3: CHROMATOGRAPHIC TECHNIQUES

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

MODULE-4: MEMBRANE SEPARATION

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

MODULE-5: CRYSTALLIZATION AND DRYING

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

Text Books

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

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

Reference Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Purification of non-protein bio molecules

POs met through Gaps in the Syllabus: PO3

Topics beyond syllabus/Advanced topics/Design:

Advance chromatographic separation processes

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE508

Course title: Biophysics

Pre-requisite(s): BE /B Tech Biotechnology/ Biochemical Engineering/ Chemical Engineering/ Food Technology or equivalent or M Sc Biotechnology/ Biochemistry/ Microbiology/ Plant Biotechnology/ Animal Biotechnology or equivalent.

Co- requisite(s): -NIL-

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

Class schedule per week: 03

Class: M.Tech.

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

CO1	Demonstrate an understanding of the building blocks of basic and modern design and conduct experiments, as well as to analyze and interpret data for related to domain of Biophysics.
CO2	Ability to apply the knowledge of various types of industrially used spectroscopic and imaging methods; advantages and disadvantages, design criteria, molecular imaging, instrumentation and various aspects of operation.
CO3	Scrutinize processes of membrane biophysics, Bio-MEMS (design and application), Electrophysiology, Neurobiophysics and Nuclear Medicine.
CO4	Assess an instruments or biophysical system for its stability, controllability, and observability properties

SYLLABUS

Module I: Biophysical basics:

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

Module II: Hydrodynamic and Bimolecular spectroscopy:

Ultracentrifugation, Principle Instrument Designs & Applications and application in biology of IR/vibrational spectroscopy, Raman spectroscopy, Fluorescence spectroscopy (FRET), Nuclear Magnetic Resonance Spectroscopy and Mass spectroscopy (8L)

Module III: Diffraction Techniques and Bioimaging:

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

Module IV: Electrostatic interactions and Membrane Biophysics:

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

Module V: Electrophysiology, Neurobiophysics and Nuclear Medicine:

Action potential and its propagation, Voltage clamp and patch-clamp techniques, Electrocardiography (principle instruments and signal analysis), Electroencephalography, Basic

principles of Nuclear Medicine, Diagnostic use of Radioisotopes In-vivo & In-vitro procedures.

(8L)

Text Books

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

Reference Books

1. Introduction to Biophysics, Bert Kappen

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Design of real-time industrial projects.

Topics beyond syllabus/Advanced topics/Design:

Bioelectronics

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

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

Indirect Assessment –

1. Student Feedback on Faculty

2. Student Feedback on Course Outcome

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE509

Course title: Bioprocess Plant Design Lab

Pre-requisite(s): BE506 Bioprocess Plant Design

Co- requisite(s): NIL

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Tech.

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

Experiment-1 Familiarization of software based process design.

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

Course Evaluation:

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

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

Topics beyond syllabus/Advanced topics/Design: Nil

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE510

Course title: Bioseparation Engineering Lab

Pre-requisite(s): BE507 Advanced Bioseparation Engineering

Co- requisite(s): NIL

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Tech.

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

List of Experiments

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

Books Recommended:

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

Course Evaluation:

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

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

Topics beyond syllabus/Advanced topics/Design: Nil

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

CO5	3	-	2	1	-	-

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE511

Course title: ENVIRONMENTAL BIOTECHNOLOGY

Pre-requisite(s):

Co- requisite(s):

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

Class schedule per week: 03

Class: M.Tech.

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module I: Introduction

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

Module II: Waste Water and Sludge Management

Modes of biological methods for waste water treatment, aerobic and anaerobic methods, activated sludge digestion process (8L)

Module III: Solid Waste Management

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

Module IV: Bioremediation

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

Module V: Biofuels and Organic Farming

Alternate Source of Energy, Biomass as a source of energy, Biomineralization, Liquid and gaseous biofuels, Microbial fuel cell, Biocomposting, Vermiculture, Biofertilizers, biopesticides. (8L)

Text Books

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

Reference Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE512

Course title: Modern Methods of Instrumentation

Pre-requisite(s):

Co- requisite(s): Nil

Credits: 3 L: 03 T:0 P:0

Class schedule per week: 03

Class: M. Tech

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

After the completion of this course, students will be:

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

SYLLABUS

Module-1: Chromatographic Techniques-I

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

(8L)

Module-2: Chromatographic Techniques-II

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

(8L)

Module-3: Atomic spectrometry

Atomic absorption, X-ray fluorescence methods Flame atomic emission and absorption, flame emission photometer, flame absorption spectrometer, spectral interferences, quantitative aspects, ICP, X-ray fluorescence principle, Instrumentation, quantitative analysis.

(8L)

Module-4: Electrophoresis

Gel electrophoresis; Types of gels, principle, apparatus and methods, gradient gels, Two-dimensional gels, isoelectric focusing, determination of molecular weight using electrophoresis, Case study.

(8L)

Module-5: Analytical and Imaging Instruments

Principle, instrumentation and application of FACS, FRET, cell on a chip, Thermogravimetry, fluorescence life time imaging (FLIM), Two photon and multiphoton microscopy.

(8L)

Text Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Students will be demonstrated on instruments with real samples, so that they can use the instruments.

POs met through Gaps in the Syllabus:**Topics beyond syllabus/Advanced topics/Design:****COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE****Direct Assessment**

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

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

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

Indirect Assessment –

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

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE513

Course title: Animal Cell Culture

Pre-requisite(s): NIL

Co- requisite(s): NIL

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

Class schedule per week: 03

Class: M. Tech.

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

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

SYLLABUS

Module 1: Basics of Cell and Tissue Culture

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

Module 2: Cell Culture Lines

Definition, development and maintenance, cloning of cell lines, cell synchronization viral sensitivity of cell lines, cell line preservation and characterization, stem cell lines. (8L)

Module 3: General Tissue Culture Techniques

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

Module 4: Methods in Cell Culture

Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection, Organ Culture, whole embryo culture. (7L)

Module 5: Applications of Animal Cell Culture

Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, Cloning for production of transgenic animals, cloning for conservation, *in-vitro* fertilization and embryo transfer. (9L)

Text Books

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

Reference Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Design of industry specific projects.

POs met through Gaps in the Syllabus: **PO5 & PO6**

Topics beyond syllabus/Advanced topics/Design:

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE514

Course title: Cell Signalling and Electrophysiology

Pre-requisite(s):

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: I/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module 1: INTRODUCTION TO CELL SIGNALLING

Introduction to cell signalling and pathways; Electrical and chemical signals in cellular communication. (8L)

Module 2: MEMBRANE POTENTIAL

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

Module 3: PLANT ELECTROPHYSIOLOGY

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

Module 4: ANIMAL ELECTROPHYSIOLOGY

Electrophysiology of nerve and muscle cells; Types of synapses and neurotransmitters; chemical synapses and pattern of interconnections; synaptic transmission; biochemical control of synaptic transmission. Motor unit and surface electromyography, electroencephalography.

(8L)

Module 5: ELECTROPHYSIOLOGY OF SPECIAL ORGANS

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

(8L)

Text Books

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

Reference Books

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Design of real time projects to meet the research and industry requirements.

POs met through Gaps in the Syllabus: PO3, PO6

Topics beyond syllabus/Advanced topics/Design

Lecture on specialised techniques in electrophysiological recordings.

Lecture on specialized electrophysiological devices.

POs met through Topics beyond syllabus/Advanced topics/Design: **PO4, PO6**

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE 515

Course title: Process Biotechnology

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

Co- requisite(s): Nil

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

Class schedule per week: 3

Class: M. Tech

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module 1: Cell growth and kinetics

Pattern of growth behaviour in batch culture, role of media on growth processes, factors affecting the process of growth and model for Product formation, Mass balance, Yield prediction.

(8L)

Module 2: Enzyme Production

Introduction to industrial enzymes, optimization processes and regulation of production, large scale production of proteases, lipases and amylases etc., immobilization and related applications.

(8L)

Module 3: Sterilization

Importance of sterilization, design of sterilization process, introduction and the kinetics of death, various type of sterilization equipments, role of filters in fermentation process and sterilization of filters.

(8L)

Module 4: Production of primary metabolites

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

Module 5: Production of secondary metabolites

Production processes of beta lactam antibiotics, penicillins and cephalosporins, semisynthetic penicillins, streptomycin, and vitamins (8L)

Text Books

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

Reference Books

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

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

Real time production process of different metabolites

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE****Direct Assessment**

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

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

Indirect Assessment –

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

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE516

Course title: Stem Cells & Tissue Engineering

Pre-requisite(s): BE502 r-DNA Tech. & Genetic Engineering

Co- requisite(s):

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

Class schedule per week: 03

Class: M. Tech.

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables students to:

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

Course Outcomes

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

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

SYLLABUS

Module-1:

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

Module-2:

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

Module-3:

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

Module-4:

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

Module-5:

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

Books Recommended

Text Books:

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

Reference Books:

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

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

POs met through Gaps in the Syllabus: Nil

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

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

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

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

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

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

Indirect Assessment

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE517

Course title: Protein Engineering

Pre-requisite(s): BE502 r-DNA Tech. & Genetic Engineering

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module-1:

Protein: Physicochemical properties of proteins, Forces determining the protein structure, Mechanisms of protein folding, molten globule structure, characterization of folding pathways. (8L)

Module-2:

Protein Structure: Spectroscopic techniques for protein structure determination, Absorption and Fluorescence, Principle, methods and applications of Circular dichroism, FT-Raman, FT-IR, X-ray crystallography, NMR, MALLS. (8L)

Module-3:

Protein Function: Principle and application of DSC, Protein denaturation, aggregation and gelation, Flow properties of proteins, Sensory properties of proteinaceous foods, Protein functionality in cereals, legume, oil seeds and pseudo cereals, Muscle protein, Milk protein, Egg protein (8L)

Module-4:

Protein Modification: Role of technological processes like Thermal, Enzymatic, Physical, Pressure, Solvents and Interactions in protein modification, Effect of technological processes on nutritional value of food proteins. (8L)

Module-5:

Protein Production: Design and construction of novel proteins and enzymes, Site directed mutagenesis for specific protein function and its production, Specific examples of protein engineering, Strategies for Industrial production of engineered proteins and their applications. (8L)

Text books:

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

Reference books:

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

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

POs met through Gaps in the Syllabus: Nil

Topics beyond syllabus/Advanced topics/Design: Nil

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

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

Direct Assessment

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

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

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

Indirect Assessment

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE518

Course title: Biomedical Instrumentation

Pre-requisite(s): Fundamentals of measurement system,
BE 514 Cell signaling and Electrophysiology

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students:

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

Course Outcomes

After the completion of this course, students will be:

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

SYLLABUS

Module 1: General Physiology

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

(8L)

Module 2: Bio-Signal Devices

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

(8L)

Module 3: Assistive, Therapeutic and Surgical Devices

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

(8L)

Module 4: Anatomical and Physiological Imaging

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

(8L)

Module 5: Biomedical Safety

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

(8L)

Text Books:

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

Reference Books:

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

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

POs met through Gaps in the Syllabus

Conducting presentations in group and writing reports.

Giving assignments to the students on some relevant topics.

Industrial visits.

POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design

Lecture on brain-computer interaction and specialized imaging devices.

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

Mapping Between COs and Course Delivery (CD) methods

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

COURSE INFORMATION SHEET

Course code: BE600

Course title: Thesis Part I

Pre-requisite(s): Nil

Co- requisite(s): Nil

Credits: 8 L: T: P:

Class schedule per week:

Class: M.Tech.

Semester / Level: III/06

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

Indirect Assessment –

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

COURSE INFORMATION SHEET

Course code: BE601

Course title: IPR, Biosafety & Bioethics

Pre-requisite(s): NIL

Co- requisite(s): NIL

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

Class schedule per week: 03

Class: M.TECH

Semester / Level: III/06

Branch: Bioengineering

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module-1: Introduction to Intellectual Property

Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Agreements and Treaties; Indian Patent Act 1970 & recent amendments.
(8L)

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

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

Module-3: Patent Filing Procedures

National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting—disclosure/non-disclosure; Financial assistance for patenting—introduction to existing schemes, Patent licensing and agreement Patent infringement—meaning, scope, litigation, case studies.
(8L)

Module-4: Biosafety

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

Module-5: Bioethics

Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.
(8L)

Text books:

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

Reference books:

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

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: PO6**Topics beyond syllabus/Advanced topics/Design:**

Real time production process of different metabolites

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

Indirect Assessment –

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

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE602

Course title: Advanced Nanobiotechnology

Pre-requisite(s):

Co- requisite(s): NIL

Credits: 3 L:03 T:0 P:0

Class schedule per week: 03

Class: M. Tech

Semester / Level: III/06

Branch: Bioengineering

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

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

SYLLABUS

Module 1: Introduction to Nanobiotechnology

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

Module 2: Nano-Materials synthesis & Characterization

Nanofabrication methods: Top-Down approaches, Bottom-Up approach, Biological approach, Nanoscale visualization & characterization techniques (8 L)

Module 3: DNA & Protein based Nanostructures

DNA–Protein Nanostructures, DNA–Gold-Nanoparticle Conjugates, Nanomotors, S-Layers (8 L)

Module 4: Emerging Nanobiotechnologies

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

Module 5: Nanomaterials application & Future Challenges

Bioimaging, Drug Delivery, Cancer nanotechnology, Hyperthermia, regenerative therapy, industrial nanotechnology, Nanotoxicity & challenges ahead (8 L)

Text books:

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

Reference books:

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

High end characterization techniques (TEM/HRTEM)

POs met through Gaps in the Syllabus: PO4

Topics beyond syllabus/Advanced topics/Design:

Advance nanomaterials

POs met through Topics beyond syllabus/Advanced topics/Design: PO4**Course Outcome (CO) Attainment Assessment tools & Evaluation procedure****Direct Assessment**

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

Mapping between Course Objectives and Program Outcomes

Mapping of Course Outcomes and Program Outcomes

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1
CO2	CD1
CO3	CD1, CD2
CO4	CD1,CD2, CD8

COURSE INFORMATION SHEET

Course code: BE603

Course title: Metabolic Engineering

Pre-requisite(s): NIL

Co- requisite(s): NIL

Credits: 3 L:03 T:0 P:0

Class schedule per week: 03

Class: M. Tech

Semester / Level: III/06

Branch: Bioengineering

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module-1:

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

(8L)

Module-2:

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

(8L)

Module-3:

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

(8L)

Module-4:

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

(8L)

Module-5:

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

(8L)

Text Book:

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

Reference Books:

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

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: NIL

Topics beyond syllabus/Advanced topics/Design: NIL

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

Indirect Assessment –

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

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BE604

Course title: Biosimulation and Modelling

Pre-requisite(s):

Co- requisite(s):

Credits: 3 L:03 T:0 P:0

Class schedule per week: 03

Class: M. Tech

Semester / Level: III/06

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

After the completion of this course, students will be:

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

SYLLABUS

Module-1:

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

(8L)

Module-2:

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

(8L)

Module-3:

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

(8L)

Module-4:

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

(8L)

Module-5:

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

(8L)

TEXT BOOKS

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

REFERENCE BOOKS

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

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: NIL

Topics beyond syllabus/Advanced topics/Design: NIL

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE**

Direct Assessment

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

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

Indirect Assessment –

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

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE605

Course title: Neuro-Muscular Rehabilitation Engineering

Pre-requisite(s): Nil

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M. Tech

Semester / Level: III/06

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

SYLLABUS

Module 1: Fundamentals of Rehabilitation Engineering

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

(8L)

Module 2: Neuromuscular Assessment

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

(8L)

Module 3: Sensory Rehabilitation

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

(8L)

Module 4: Assistive Technology in Vision

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

(8L)

Module 5: Challenges in Rehabilitation Engineering

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

(8L)

Text Books

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

Reference Book

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

Gaps in the syllabus (to meet Industry/Profession requirements)**POs met through Gaps in the Syllabus**

Conducting presentations in group and writing reports

Giving assignments to the students on some relevant topics

POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design :

Lecture on special sensory organs

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

**COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION
PROCEDURE****Direct Assessment**

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHODS

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

COURSE INFORMATION SHEET

Course code: BE606

Course title: Process Biotechnology Lab

Pre-requisite(s): BE515 Process Biotechnology

Co- requisite(s): Nil

Credits: 2 **L:** 0 **T:** 0 **P:** 4

Class schedule per week: 04

Class: M.Tech.

Semester / Level: III/06

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

LIST OF EXPERIMENTS:

Experiment-1	Isolation of proteolytic enzymes from soil sample
Experiment-2	Production of citric acid
Experiment-3	Production of baker's yeast
Experiment-4	Preparation of standard plot of protein
Experiment-5	Preparation of standard plot of sugar
Experiment-6	Growth of microorganism and mass balance
Experiment-7	Immobilization of whole cell by entrapment
Experiment-8	Kinetic study of enzyme

Books:

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

Course evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Assignment of different projects of industrial significance

POs met through Gaps in the Syllabus: PO6

Topics beyond syllabus/Advanced topics/Design:

Real time production process of different metabolites

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE
DELIVERY METHOD**

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

COURSE INFORMATION SHEET

Course code: BE607

Course title: Animal Cell Technology Lab

Pre-requisite(s): BE513 Animal Cell Culture

Co- requisite(s): Nil

Credits: 2 **L:** 0 **T:** 0 **P:** 4

Class schedule per week: 04

Class: M.Tech.

Semester / Level: III/06

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students:

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

Course Outcomes

After the completion of this course, students will be:

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

LIST OF EXPERIMENTS

Experiment-1 Laboratory Design & Instrumentation in ACT.

Experiment-2 Quality Assurance in Animal tissue culture facility.

Experiment-3 Sterilization Techniques in ACTL.

Experiment-4 Preparation of animal cell culture media.

Experiment-5 Isolation and Culturing of Peripheral Blood Lymphocytes.

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

- Experiment-7** Sub-culturing and maintenance of Cell line.
- Experiment-8** In vitro anticancer assay (MTT Assay).
- Experiment-9** DPPH radical scavenging assay.
- Experiment-10** Genomic DNA Isolation from animal tissues.

Text Books

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

Reference books:

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

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

POs met through Gaps in the Syllabus

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics

POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design

1. Lecture on advanced application of animal cell culture technology
2. Lecture on different case studies and state-of-art techniques.

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

Continuous Internal Assessment	% Distribution
Quizzes	10

Day to day performance & Lab files	30
Viva	20

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

Indirect Assessment –

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN CURSE OUTCOMES AND COURSE DELIVERY METHODS

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

COURSE INFORMATION SHEET

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

Course Objectives

This course enables the students:

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

Course Outcomes

After the completion of this course, students will be:

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

LIST OF EXPERIMENTS

Experiment 1: To study and calculate body mass index and its correlation with human health.

Experiment 2: To study different types of electrodes and sensors used in bio-potential recordings.

Experiment 3: To study and measure the non-invasive blood pressure using sphygmomanometer

(a) To evaluate the diastolic pressure.

(b) To evaluate systolic pressure.

(c) To evaluate mean arterial pressure.

Experiment 4: To record and analyse the characteristics of different types of electrolytic medium between electrode and body.

(a) Air-coupled.

(b) Applied water.

(c) Applied electrolytic gel.

(d) Applied disposable electrodes.

Experiment 5: To record and analyse bipolar electrocardiogram for different leads under varied sensory, motor and visual stimulus.

Experiment 6: (a) To record and analyse surface electromyogram in calculating clench strength for both dominating and non-dominating arm with lowest applied clench force.

(b) To record and analyse surface electromyogram in calculating clench strength for both dominating and non-dominating arm with highest applied clench force.

Experiment 7: (a) To record and analyse vertical and horizontal eye ball activity while gazing stationary objects.

(b) To record and analyse vertical and horizontal eye ball activity while tracking moving Objects.

Experiment 8: (a) To record and analyse the phonocardiogram signal.

(b) To correlate the PCG signal with electrical and mechanical cardiac activities.

Experiment 9: (a) To record biopolar and monopolar electroencephalogram (EEG).

(b) To Derive and analyse delta, theta, alpha and beta bands of EEG.

Experiment 10: To study and analyse haemodynamic activity using pulse plethysmography.

Experiment 11: To record and analyse electrodermal activity or galvanic skin response.

Experiment 12: To study and perform lie detector test.

Text Books

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

Reference Books

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

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

POs met through Gaps in the Syllabus

3. Conducting presentations in group and writing reports
4. Giving assignments to the students on some relevant topics

POs met are: **PO2, PO6**

Topics beyond syllabus/Advanced topics/Design

3. Lecture on specialized physiological sensing
4. Lecture on human-machine interaction

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

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

Indirect Assessment –

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

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

Mapping Between Course Outcomes and Course Delivery Methods

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

COURSE INFORMATION SHEET

Course code: BE650

Course title: Thesis Part II

Pre-requisite(s): Nil

Co- requisite(s): Nil

Credits: 16 L: T: P:

Class schedule per week:

Class: M.Tech.

Semester / Level: IV/06

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

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

Course Outcomes

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

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

COURSE OUTCOME (CO) ATTAINMENT ASSESSMENT TOOLS & EVALUATION PROCEDURE

Direct Assessment

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

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

Indirect Assessment –

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

DEPARTMENT OF BIO-ENGINEERING
BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
M. Tech. (Biotechnology)

Course Structure

Eligibility: BE /B Tech Biotechnology/ Biochemical Engineering/ Chemical Engineering/ Food Technology or equivalent with valid GATE Score or
M Sc Biotechnology/ Biochemistry/ Microbiology/ Plant Biotechnology/ Animal Biotechnology or equivalent and Math in 10+2 level with valid GATE Score.

Semester 1

Sl. No.	Subject code	Offering Department	Name of the Subject	L (h/week)	T (h/week)	P (h/week)	Credits
1	TBT 1001	BT	Bioprocess Engineering	3	1	0	4
2	TBT 1003	BT	r-DNA Technology & Genetic Engineering	3	0	0	3
3	TBT 1005	BT	Biophysics	3	0	0	3
4		Other	BR1	3	0	0	3
5		BT	Elective 1	3	0	0	3
6	TBT 1002	BT	Lab I- Bioprocess Engineering	0	0	3	2
7	TBT 1004	BT	Lab II- r-DNA Technology	0	0	3	2
8	TBT NC1	AP	Non-credit Course: Data structure /Biostatistics	3	0	0	0
			Seminar/Assignment		1		
	Total Credits						20

BR1: MSH 1103 – Business Ethics

Elective 1: TBT 1011- Animal Biotechnology
TBT 1017- Protein Engineering

Semester 2

Sl. No.	Subject code	Offering Department	Name of the Subject	L (h/week)	T (h/week)	P (h/week)	Credits
1	TBT 2001	BT	Bioprocess Plant Design	3	1	0	3
2	TBT 2003	BT	Downstream Processing	3	0	0	4
3	TBT 2005	BT	IPR, Biosafety & Bioethics	3	0	0	3
4		BT	Elective 2	3	0	0	3
5		BT	Elective 3	3	0	0	3
6	TBT 2002	BT	Lab III- Bioprocess Plant Design	0	0	3	2
7	TBT 2004	BT	Lab IV- Downstream Processing	0	0	3	2
8	TBT NC2	DM	Non Credit course: Bioentrepreneurship	3	0	0	0
			Seminar /Assignment		1		
	Total Credits						20

Semester 3

		L (h/week)	T (h/week)	P (h/week)	Credits
TBT 3002	Thesis 1	0	0	--	15
Total Credits					15

Semester 4

		L (h/week)	T (h/week)	P (h/week)	Credits
TBT 4002	Thesis 2	0	0	--	20
Total Credit					20

Total Credit in all Semesters

$$20+20+15+20 = 75$$

L= Lecture; T= Tutorial; P= Practical

List of Electives:

Elective 1	TBT 1011	Animal Biotechnology
	TBT 1015	Pharmaceutical Biotechnology
	TBT 1017	Protein Engineering
	TBT 1018	Process Technology
	TBT 1023	Nanobiotechnology
Elective 2	TBT 2011	Immunotechnology
	TBT 2021	Computational Biology
	TBT 2023	Environmental Biotechnology
	TBT 2017	Reaction Engineering
	TBT 2027	Biospectroscopy and Image Analysis
Elective 3	To be offered by Other Department	Open Electives
	To be Proposed later by the dept	

Breadth Paper to be offered by BT:

BR1	TBT 1028	Computational Biology
	TBT 1029	IPR, Biosafety and Bioethics
	TBT 1030	Industrial Biotechnology

SEMESTER 1

1. Bioprocess Engineering (TBT 1001)	Credits 3

Module I

Principles of enzyme catalysis: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for more complex enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems, brief introduction to large scale enzyme production.

Module II

Medium constituents, Designing of fermentation medium and its optimization. Improvement of industrially important microbes.

Module III

Microbial growth: Introduction to metabolism; Nutrient transport; Glycolysis; TCA cycle and other pathways; Control of metabolism; Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.

Module IV

Bioreactors: Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/mammalian cell culture reactors.

Module V

Agitation and aeration: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (kLa), measurement of kLa, power requirement for agitation in gaseous and non gaseous systems.

Module VI

Scale up, operation and control of bioreactors: Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control.

Module VII

Industrial Processes and Process economics: Description of industrial processes; Process flow sheeting; Process economics

Books Recommended:

1. Lee, Biochemical Engineering
2. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
3. Aiba and Humphrey. Biochemical Engineering
4. Doran, Bioprocess Engineering Principles
5. Bailey and Ollis, Biochemical Engineering Fundamentals

Texts/References

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
2. Pauline Doran, Bioprocess engineering principles, 1 Edition, Academic Press, 1995.
3. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.
4. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

2. TBT 1003: r-DNA Technology & Genetic Engineering	Credits 3

Module I

Basics Concepts: DNA Structure and properties; Restriction and DNA modifying enzymes; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA using different techniques; Hybridization techniques: Southern, Northern, Colony and Fluorescence and *in situ* hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay.

Module II

Cloning Vectors: Plasmids; Bacteriophages; M13 mp vectors; Phagemids; Insertion and Replacement vectors; EMBL; Shuttle vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/baculo & retroviral vectors; Expression vectors (eukaryotic and prokaryotic); Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Plant based vectors, Ti and Ri as vectors, Yeast vectors

Module III

Cloning Methodologies: Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Metagenomics and its role in environment, Expression cloning; Jumping and hopping libraries; Southwestern and Farwestern cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array, Introduction of DNA into mammalian cells; Transfection techniques

Module IV

PCR and Its Applications: Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; PCR in molecular diagnostics; Viral and bacterial load detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

Module V

Sequencing methods: Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; Next generation DNA sequencing techniques, RNA sequencing; Chemical Synthesis of oligonucleotides;

Module VI

Gene silencing techniques: Small double stranded RNAs; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing;

Module VII

Gene knockouts and Gene Therapy: Creation of knock out *C. elegans*, *Arabidopsis* and mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting;

Text/References:

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

3. TBT 1005: Biophysics	Credits 3

Module I

Biophysical basics: Schrodinger's theory, Quantum numbers, Heisenberg uncertainty principle, Vander waals forces, Electro chemical cell, Brownian Motion.

Module II

Hydrodynamic and Bimolecular spectroscopy I: Centrifugation & Ultracentrifugation, Viscometry, Instrument Design, Methods & Applications of UV-Visible Spectra, IR Spectra, Raman Spectra, Fluorescence spectra, NMR Spectra., Linear and Circular Dichroism, Nuclear Magnetic Resonance Spectroscopy.

Module III

Diffraction Techniques and Bimolecular spectroscopy II: Bragg's Law X ray diffraction by crystals. Principle, Instrument Design, Methods & Applications of Polarimetry, Flowcytometry, Raman spectroscopy, vibrational spectroscopy in biology, Mass Spectrometry .

Module IV

Microscopy: Phasecontrast, Fluorescence, Scanning & Transmission Electron Microscopy, CCD Camera, Introduction to Atomic Force Microscopy

Module V

Membrane Biophysics: Relation between membrane potential & cell characteristics, Zeta, Stern & total electrochemical potential, Helmholtz-Smoluchowski equation, Transmembranes potential & it's measurement by microelectrodes. Role of carriers in ion transport (ex: -Valinomycin & gramicidin), Transporting ATPase-Na-K ATPase.

Module VI

Neurobiophysics and Applications of Radioactivity: Synaptic transmission, Physicochemical basis of membrane potential, Resting and action potential, Propagation of action potential, Voltage clamp and patch-clamp techniques, Autoradiography, General principles, Types & constitutions of photographic emulsion.

Module VII

Electrophysiology and Nuclear Medicine: Principles of Electrocardiography, Heart- an electric potential sources, ECG waveforms, Standard lead systems, ECG preamplifiers, ECG readout devices, ECG machine, Measurements, Principles of Electroencephalography, Basic principles of Nuclear Medicine, Diagnostic use of Radioisotopes In-vivo & In-vitro procedures.

Text Books

Reference Books

4. TBT NC 11: Data structure in C++ or	Certificate course
5. TBT NC 12: Biostatistics	

Syllabus should be provided later

6. TBT 1002: Lab I-Bioprocess Engineering Lab	Credits 3

Experiments based on the theory

7. TBT 1004: Lab II-rDNA Technology	Credits 3

Experiments based on the theory

Electives 1

8. TBT 1011: Animal Biotechnology	Credits 3

Module I

Techniques in animal tissue culture: Primary and secondary cell culture and maintenance; Embryonic fibroblast isolation and culture; stem cell isolation and cultures; measurement of cell

viability/ toxicity, cell separation, development and, in vitro culture of oocytes/ embryo, cryopreservation and transport of germplasm; Embryonic and pluripotent stem cell culture and sorting;

Module II

Organ and histotypic cultures: cell synchronization, Bioreactors for tissue/ mass culture, design, characterization and recent development (scaling up animal cell culture; In Vitro fertilization and embryo transfer; Tissue engineering; Polyclonal and monoclonal antibody production; Organ Culture

Module III

Transgenesis: Gene propagation methods; Use of cloning and expression vectors, Adeno viral vectors and Baculoviruses; Genetically engineered proteins, vaccines, hormones etc. produced in the host; newly emerging transgenic tools.

Module IV

Medical Molecular Biology: Use of nucleic acid and antibodies as a specific probe in clinical diagnosis and tissue typing; custom made animals as different disease models comparable to human system; Gene therapy and its utilization; Protein and DNA vaccines; Production of Edible vaccines in plant system; synthetic DNAs; drug delivery. Cloning and xenotransplantation.; Gene mapping.

Module V

Animal and human genome projects: the human genome; goals of human genome projects; genetic linkage maps; polymorphic DNA markers; physical map; integrating genetic linkage and physical map; DNA sequencing; ethical, legal, and social implications. Use of molecular biology in forensic medicine RFLP and applications

Module VI

Ethical issues in animal biotechnology: Management aspects of biotechnology and genetic engineering. Discussion about current developments in animal biotechnology. Historical perspectives, sterilization methods, organ culture - culture techniques, plasma clot, raft methods, agar gel, grid method, organ engineering. Cell culture substrates, cultural media, natural and artificial media, initiation and maintenance of cell cultures, cell culture products, cryopreservation techniques, in vitro fertilization and embryo transfer, Somatic cell hybridization, hybridoma technology.

Module VII

Animal genetic engineering: Chemical and electrochemical gene transfection methods - microinjection, viral and other methods of gene transfection; Production of transgenic animals with new traits using embryonic stem cell; Use conditional knockouts for the lethal genes; Use transgenic animals for producing important compounds required for pharmaceutical and therapeutic purposes; Bioethical issues related to animal biotechnology, Molecular markers.

Text & References:

Text:

1. Animal Cell biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.
2. Animal Biotechnology: Murray Moo-Young (1989), Pergamon Press, Oxford.

References:

- Molecular Biotechnology: Primrose.
- Living resources for Biotechnology, Animal cells: A. Doyle, R. Hay and B.E. Kirsop (1990), Cambridge University Press, Cambridge.
- Barnum's Biotechnology. D.C. Darling and S.J. Morgan, 1994, Animal Cells Culture and media, BIOS Scientific Publishers Limited.
- Jennie P. Mather and David Barnes, 1998, Methods in Cell Biology, Volume 57: Animal Cell Culture Methods Academic Press.

9. TBT 1015: Pharmaceutical Biotechnology	Credits 3

Module I

Introduction and history of pharmaceutical Biotechnology: Scope of biotechnology in pharmacy and medical sectors, Enzymes and immobilized enzymes in therapy and diagnosis, fermentation and biological products in medical sector.

Module II

Genomics and its impact on medicine: Rational drug design processes-introduction to QSAR, 3-D QSAR; genetic counseling and gene testing; cancer- oncogenes, tumor suppressor genes and growth factors.

Module III

Pharmacogenomics: Hereditary disorders, Single nucleotide polymorphism (SNP) and its application in molecular medicine and personal medicine, Pharmacogenomics based approaches for cancer, diabetes, hypertension and Alzheimer's disease, etc.

Module IV

Gene therapy: Principles, methods and applications of gene therapy, viral, non-viral systems for gene therapy, gene therapy case studies – cancer, inborn errors and hematopoietic disorders.

Module V

Genetically engineered pharmaceuticals: Concept and method for production of r-therapeutics with reference to insulin, growth hormone, hematopoietic growth factors, hepatitis B vaccine and interferon.

Module VI

Diagnostic biotechnology: Principles of monoclonal antibodies production, design and development of ELISA kit, monoclonal antibodies in disease detection and treatment, role of PCR in microbial, plant and animal cell/virus detection.

Module VII

Pharmaceutical Industry: Layout, GMP (Good Manufacturing Practices), Introduction to various dosage forms, Stability of the prepared products, concept of expiry date, Pharmaceutical Products and Ethical Issues.

Text Books:

1. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Oliver Kayser, Rainer H. Miller, Wiley Interscience, March 2004
2. Pharmaceutical Biotechnology by S.P. Vyas, V.K.Dixit, 1st ed,CBS Publishers & Distributors, New Delhi, 1998
3. Pharmaceutical Biotechnology by Daan J.A. Crommilin & Robert D. Sindelar (eds.) Routledge, Taylor & Francis group, London 2002

References Books:

1. Biotechnology and Biopharmaceuticals by Rodney J.Y. Ho and Milo Gibaldi, Wiley Liss Sons Inc. publications, New Jersey.Controlled Release Veterinary Drug Delivery M.J. Rathbone & R. Gurny, Elsevier JUL-2000
2. Controlled and Novel Drug Delivery Marcel Dekker, Robinson, J.R. & Lee, V.H.I.,: New York and Basel.
3. Pharmaceutical Management by Smith
4. Establishment of a pharmaceutical factory by Aganil
5. Dispensing for Pharmaceutical students by Cooper and Gunn's
6. The Science and Practice of Pharmacy by Remington
7. The Theory and Practice of Industrial Pharmacy by Lachman, Lieberman & Kanig

10. TBT 1017: Protein Engineering	Credits 3

Module 1

Protein: general introduction, forces that determine protein structure and physicochemical properties. Mechanisms of protein folding, molten globule structure, characterization of folding pathways.

Module II

Determination of protein structure: various spectroscopic techniques for protein structure determination. Background and basic principles, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, NMR, X-ray crystallography, MALLS.

Module III

Thermal properties of proteins: application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of proteinaceous foods.

Module IV

Protein functionality. Protein raw materials- cereals, legume, oil seeds and pseudo cereals. Muscle protein, Milk protein, Egg protein.

Module V

Protein modification as result of technological processes: thermal, enzymatic, physical, pressure, solvents, interactions.

Module VI

Nutritive role of food proteins.

Module VII

Design and construction of novel proteins and enzymes. Site directed mutagenesis for specific protein function, Basic concepts for design of a new protein/enzyme molecule, Specific examples of enzyme engineering.

Text & Reference Books:

1. Carl, Branden and Tooze, John. Introduction to Protein Structure, Garland Publishing (Taylor and Francis Group). New York.
2. Yada, R. Y.; Jackman, R. L.; Smith, J. L. Protein Structure-Function Relationships Blakie Academic and Professional: London
3. Clark, R. J. H and Hester, R. E. Spectroscopy of Biological Systems, John Wiley and Sons, New York
4. Nakai, S. and Modler, H. W. Food Proteins: Properties and Characterization, VCH Publishers, New York.

11. TBT 1018: PROCESS TECHNOLOGY	Credits 3

PROCESS TECHNOLOGY

Module 1:

Introduction to chemical calculations, units, dimensions, chemical equation, stoichiometry.

Module 2:

Material balance fundamentals, Energy balance concepts, units, enthalpy, Heat of solution & mixing, Humidity Chart.

Module 3:

Basic equation of fluid flow, Newtonian, non-Newtonian fluids, Reynolds's number, continuity equation, Bernoulli equation, fluid friction, flow in pipes, Hagen- Poiseuille equation, Sudden Expansion and Contraction, Transportation and Metering of fluids.

Module 4:

Heat transfer- conduction, Fourier's law, convection-forced & natural convection. Radiation- Kirchhoff's law, Stefan- Boltzmann law, view factors, combined heat transfer.

Module 5:

Phase rule & phase diagram, azeotropes, distillation, Leaching, Adsorption, Absorption, and Diffusion.

Module 6:

Design calculations, P&ID, utility, valves, pumps, compressors, piping & vessels, heat exchanger, process diagrams, distillation systems, separation systems. Techno feasibility Concepts

1. TBT 1023: Nanobiotechnology	Credits 3

Module I

Functional Principles of Nanobiotechnology: From Biotechnology to Nanobiotechnology. What is Nanobiotechnology? Information-Driven Nanoassembly, Energetics, Topdown and bottom up approach for building nanomaterials, Chemical Transformation Biomaterials, Machine-Phase Nanobiotechnology

Module II

Structural Principles of Nanobiotechnology

Construction of Nanomachines, The Raw Materials: Biomolecular Structure and Stability, Protein Folding, Self-Assembly, Self-Organization, Molecular Recognition, Atomicity limits the tolerance of combining sites, Flexibility, Flexibility poses great challenges for the design of , nanobiomachines

Module III

Nanobiomachines in Action: The Unfamiliar World of Nanobiomachines, Modern nano biomachine using different molecular motors, Biomaterials created by nano particle, Biomaterial supplementing important human body part, Guided Tour of Natural Nanobiomachinery

Module IV

Biosensors as Precursors of Bioelectronics, Functionalization of Sensing Substrates, Biochip, Nanosensors-Miniaturization of Biosensors, Nanomaterial Based Biosensors. Electron Transfer of Biomolecules, Nanoparticle-Biomaterial Hybrid Systems for Sensing and Electronic Devices, Effect Biosensor in biological and physicochemical techniques

Module V

DNA Templated Electronics, Sequence –specific molecular lithography, Single Biomolecule Manipulation for Bioelectronics, DNA as a semiconductor.

Module VI

Applications of nanobiotechnology in early medical diagnostics, drug targeting, drug delivery, nanosurgery and other biomedical field.

Module VII

The Future of Nanobiotechnology: A Timetable for Nanobiotechnology, Lessons for Molecular Nanotechnology, Case Studies: Nanotube synthesis; A general nanoscale assembler, Nanosurveillance. Ethical Considerations. Respect for life, Potential dangers.

Books:

Elective 2

2. TBT 2011: Immunotechnology	Credits 3

Module I

Immune System: Immunodeficiency Conditions, Lymphocyte Traffic, Innate and adoptive immune response in protection

Module II

Antigen and antibody molecules: Antigen engineering for better immunogenicity, Use for vaccine development, Antibody engineering, Antibody for diagnosis, Antibody for therapy

Module III

Theoretical basis of immunotechniques, antigen-antibody interaction, mathematical laws and deviation.

Module IV

Precipitation based techniques: immunodiffusion, immunoelectrophoresis, Rocket immunoelectrophoresis. Agglutination based techniques, dope testing, pregnancy testing and blood typing

Module V

General techniques: Western Blotting, ELISA, ELISPOT, FACS, Skin test, HLA typing, immunophenotyping, immunohistochemistry, immunoelectromicroscopy, immunofluorescence

Module VI

Molecular diagnostics: PCR based, microarray, FISH, comet assay, polymorphism studies

Module VII

Autoradiography, X-ray, PET, MRI

Books:

3. TBT 2021: Computational Biology	Credits 3

Module 1

Unix environments: Overview of File System Hierarchy Standard (FHS), Unix basic commands, text-editor, setting up compiler environment, Linux Command line Installation of tools, Using libraries- GNU scientific library (GSL).

Module II

Basics in C: Types, Operators, Expressions, Control Flow, Functions, Pointers and Arrays, Structures, Input and Output, Headers and libraries, Tricks.

Module III

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

Module IV

Data Structure: Arrays, Linked lists, Stacks (example: expression evaluation) and Queues. Binary search trees, Red-Black trees, Hash tables.

Module V:

Perl basics: text handling- regular expression, Application of perl to Bio-sequence analysis. Bioperl: Introduction, Objects and Classes and Applications: Sequences Alignments

Module VI

Biological sequence analysis: Sequence Alignment, Scoring matrices, PAM and BLOSUM, Local and Global alignment concepts, dynamic programming methodology: Needleman - Wunsch algorithm, Smith – Waterman algorithm, BLAST and FASTA, Statistical significance of BLAST hits., Multiple Sequence alignment, Progressive alignment, Heuristic methods for database searching, Methods for Phylogenetic estimation: Maximum parsimony, Distance Matrix Methods and Maximum Likelihood Methods.

Module VII

Structure prediction: Introduction to Protein Structure, Protein Secondary Structure prediction methods: Statistical methods of Chou and Fasman, Garnier-Osguthorpe-Robson, Fold Recognition and threading methods, Comparative modeling of proteins: Template Selection, Backbone modeling, loop building (search/generation), side chain generation and model evaluation and validation), Molecular Dynamics and Simulation: Energy minimization techniques, Molecular Dynamics simulations, Monte Carlo Simulations, Molecular visualization and graphics. Solvent accessible surfaces

Textbook:

1. Brian W. Kernighan and Rob Pike, The UNIX Programming Environment, Pearson Education (Indian reprint, 2003) ISBN: 81-297-0074-3.
2. Kernighan, Brian W. and Dennis M. Ritchie. 1988. The C Programming Language. 2nd ed. Prentice Hall PTR.
3. T.H. Cormen, C.E. Leiserson, and R.L. Rivest, Introduction to Algorithms, The MIT Press, Cambridge, Massachusetts, USA, 1990
4. James Tisdall, Beginning Perl for Bioinformatics: An Introduction to Perl for Biologists, O'Reilly Media
5. James L. Antonakos and Kenneth C. Mansfield, Practical Data Structures Using C/C++, Prentice Hall (1999) ISBN: 01-302-6864-X.

6. David W. Mount (2001) Bioinformatics: Sequence and Genome Analysis. Cold Spring harbor Press
7. A.R. Leach: Molecular Modelling. Longman Singapore Publishers 1996

4. TBT 2023: Environmental Biotechnology	Credits 3

Module I:

Principles and Concepts of Environment: Ecosystem: types, characteristics, structure and function. Concept of biosphere. Food chains, food webs and trophic structures. Ecological pyramids, Biodiversity and its conservation strategies: global scenario, Natural resources, Current status of major resources. Population ecology.

Module II:

Environmental Pollution and Current Environmental Issues: Environmental Pollution and its impacts, Global warming and greenhouse effect, Global Ozone Problem, Acid rain, Land degradation, Biomagnification.

Module III:

Waste Water management: Need for water management, Conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic, and fermentative bacteria, emerging biotechnological processes in waste water treatment, Eutrophication, Effects of eutrophication on the quality of water environment, factors influencing eutrophication. Algae in eutrophication, algal blooms, Physico-chemical and biological measures to control.

Module IV

Solid waste management: Industrial solid waste; Domestic solid waste; Agricultural solid waste; Municipal solid waste; Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic waste and hazardous wastes: source management and safety.

Module V:

Environment protection through Biotechnology: Biodegradation and bioremediation of pollutants, Biomineralization, Biofertilizers, Biopesticides and Vermicomposting, degradative plasmids, release of genetically engineered microbes in environment.

Module VI

Biomass energy and biofuels: Production of Biodiesel: components and operation of a biodiesel processing system, production of Bioethanol, Bioelectricity: microbial fuel cells, factor affecting the current generation, Direct biomass combustion and co-firing technologies

Module VII:

Environmental Quality Assessment and Protection Acts: Environmental Protection standards in India, Environmental impact assessment, Environmental Legislations: National and

international status, Environmental Planning for sustainable development, Kyoto protocol, Copenhagen summit 2010.

Text & References:

Text:

- Fundamentals of ecology: M. C. Dash, TMH Publication
- Text Book of Environmental Biotechnology, Pradipta Kumar Mohapatra

References:

- Ecology, Odum
- Environmental Chemistry, AK De
- Environmental Biotechnology, BD Singh
- Wastewater Engineering, Metcalf and Reddy
- Bioremediation Protocols, Sheham
- Biotechnology of Biofertilizers, Kannaiyan
- Manual of Environmental Microbiology, Hurstetc
- Environmental Microbiology: W.D. Grant & P.E. Long, Blakie, Glassgow and London.
- Biotreatment Systems, Vol. 22, D. L. Wise (Ed.), CRC Press, INC.
- Standard Methods for the Examination of Water and Waste Water (14 th Education), 1985. American Public health Association.

5. TBT 2017: Reaction Engineering	Credits 3

Module 1

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 II

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 III

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 IV

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, Design of multiple reactions in batch, CSTR and PFR,

Module V

Energy balance equations: equations for batch, CSTR and PFR and their application to the design of reactors, concepts of non-ideality, residence time distribution of fluids in vessels, models for non-ideal flow.

Module VI

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, advantages and disadvantages of packed bed and fluidized bed catalytic reactors.

Module VII

Biochemical reaction systems: enzyme fermentation, Michaelish-Menten kinetics, inhibition by foreign substances, kinetics of competitive and noncompetitive inhibitions, microbial fermentation, batch fermentor and mixed flow fermentor, kinetic expressions of fermentation.

Books Recommended:

1. Levenspiel, O. Chemical Reaction Engineering Ed.3, John Wiley & Sons (Asia)
2. Smith, Chemical Engineering Kinetics.
3. Foggler, Elements of Chemical Reaction Engineering

1. TBT 2027: Biospectroscopy and Image Analysis	Credits 3

Syllabus will be provided later

2. TBT 1025: Metabolic Engineering	Credits 3

Module I

Molecular Biology and Cellular Metabolism: Overview of molecular biology and cellular metabolism, Different models for cellular reactions, Metabolic regulation network at enzyme level and whole cell level.

Module II

Basic concepts of Metabolic Engineering: Identification of metabolic regulation is a key point in metabolic engineering. Overview of cellular metabolism, Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feed back regulation.

Module III

Modeling of metabolic networks: Stoichiometry, kinetics, mass balances for the steady state, mass balances for the transient case

Module IV

Metabolic flux analysis: Linear programming, Cell Capability Analysis, Genome Scale, isotope labeling, Integration of anabolism and catabolism. Experimental determination method of flux distribution, Metabolic flux analysis and its applications, Thermodynamics of cellular processes

Module V

Metabolic control analysis: nonlinear programming, Synthesis and design of metabolic networks - integer programming, - mixed-integer nonlinear programming Case studies - ethanol production, amino acid biosynthesis, metabolism in bacteria and yeast.

Module VI

Metabolic engineering with Bioinformatics: Metabolic pathway modeling, Analysis of metabolic control and the structure, metabolic networks, Metabolic pathway synthesis algorithms.

Module VII

Applications of Metabolic Engineering: Application in pharmaceuticals, chemical bioprocess, food technology, agriculture, environmental bioremediation and biomass conversion.

Text & References:

Text:

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

- Biochemistry by J. M. Berg, J. L. Tymoczko and Lubert Stryer (2002) Fifth Edition, W.H. Freeman, New York.
- Understanding the Control of Metabolism by David Fell (1997) Portland Press, London,.
- Metabolism at a Glance by J. G Salway (1994) Blackwell Scientific Publications, Oxford,.
- Systems Biology: Properties of Reconstructed Networks. B. O. Palsson, Cambridge University Press, 2006.
- Modeling Metabolism with Mathematica. P. J. Mulquiney and P. W. Kuchel, CRC Press, 2003.
- Pathway Analysis and Optimization in Metabolic Engineering. N. V. Torres and E. O. Voit, Cambridge University Press, 2002.
- The Regulation of Cellular Systems. R. Heinrich and S. Schuster, Chapman & Hall, 1996.
- Metabolic network reconstruction: Nature Reviews Genetics (2006) 7:130-141.
- Metabolic modelling approaches: Journal of Biotechnology (2002) 94: 37-63, Biotechnology and Bioengineering (2003) 84: 763-772
- Flux Balance Analysis: Current Opinion in Biotechnology (2003) 14: 491-496., Nature Reviews Microbiology (2004) 2: 886-897

SEMESTER 2

3. TBT 2001: Bioprocess Plant Design	Credits 3

Module I

Introduction; general design information; Mass and energy balance;

Module II

General information of Piping and instrumentation for Bioprocessing; Materials of construction for bioprocess plants; Mechanical design of process equipment;

Module III

Vessels for biotechnology application; Design of fermenters; Design considerations for maintaining sterility of process streams processing equipment;

Module IV

Selection and specification of equipment for handling fluids and solids; Selection, specification, design of heat and mass transfer equipment used in bioprocess industries;

Module V

Design of facilities for cleaning of process equipment used in biochemical industries;

Module VI

Utilities of biotechnology production plants; Process economics; Bioprocess validation; Safety considerations;

Module VII

Case studies.

Text & References:

Text:

- Plant Design and Economics for Chemical Engineers, M. Peters and K. Timmerhaus, McGraw-Hill.
- Applied Process Design for Chemical and Petrochemical Plants, E.E. Ludwig, Butterworth-Heinemann.

References:

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

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

1. Downstream Processing (TBT 2003)	Credits 3

Module I

An overview of Recovery processes, Characteristics of bioproducts; Removal of microbial cells and other solid matters, Coagulation, Flocculation and conditioning of broth.

Module II

Cell disruption techniques; Mechanical and non mechanical methods, Centrifugation and filtration

Module III

Protein precipitation and separation, Aqueous- two- phase extraction , Adsorption-desorption processes.

Module IV

Chromatographic methods of separation based on size, charge, hydrophobic interactions and biological affinity

Module V

Membrane based separation; Dialysis, Electrodialysis; Micro filtration, Ultra filtration; Electrophoresis

Module VI

Alternative Separation methods: in situ recovery, Super critical extraction, Reverse micelles extraction, Pervaporation.

Module VII

Crystallization; Drying

Texts/References:

1. E L V Harris and S. Angal, Protein Purification Methods, Ed. IRL Press at Oxford University Press, 1989.
2. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication, 1988.
3. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.
4. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.

4. TBT 2005: IPR, Biosafety & Bioethics	Credits 3

Module I

Introduction to Intellectual Property: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Module II

Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

Module III

Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTSCOPE(WIPO), IPO, etc.)

Module IV

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

Module V

Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals;

Module VI

Biosafety guidelines: Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including; Cartagena Protocol.

Module VII

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

Texts/References:

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

Important Links:

<http://www.w3.org/IPR/>

<http://www.wipo.int/portal/index.html.en>

http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html

www.patentoffice.nic.in

www.iprlawindia.org/ - 31k - Cached - Similar page

<http://www.cbd.int/biosafety/background.shtml>

<http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm>

<http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html>

5. TBT NC 21: Bioentrepreneurship	Certificate course

Module I

Introduction to entrepreneurship, Concept of entrepreneurship, Fundamentals of Marketing

Module II

Entrepreneurship traits & motivation, Growth of entrepreneurship, The marketing and selling of Biotechnology, Creating and marketing the image of the biotechnology company, Effective advertising and marketing..

Module III

Entrepreneurial development, training, institution in aid of entrepreneur, Power and importance of Positioning of a company name and product.

Module IV

Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, Workable marketing and the strength of distribution.

Module V

Opportunities in international marketing and lessons to be learned.

Module VI

Problems & solution of entrepreneurship, risk & benefit

Module VII

Steps involved in commercialization of a biotechnological product. Case studies.

Text & References:**Text:**

1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay Publications

2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication
3. Entrepreneurship development in India; Samiuddin, Mittal Publication

References:

- Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market
- Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006.
- Design and Marketing of New Products by Urban and Hauser, ISBN 0-13-201567-6
- Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences The national academy press

6. TBT 2002: Lab III- Bioprocess Plant Design	Credits 3

Experiments and exercise based on the theory

7. TBT 2004: Lab IV-Downstream Processing	Credits 3

Experiments based on the theory

Elective 3 : To be offered by other department.

8. TBT 1029: IPR, Biosafety and Bioethics	Credits 3

Module I

Introduction to Intellectual Property: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Module II

Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

Module III

Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTSCOPE(WIPO), IPO, etc.)

Module IV

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

Module V

Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals;

Module VI

Biosafety guidelines: Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including; Cartagena Protocol.

Module VII

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

Texts/References:

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

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<http://www.w3.org/IPR/>

<http://www.wipo.int/portal/index.html.en>

http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html

www.patentoffice.nic.in

www.iprlawindia.org/ - 31k - Cached - Similar page

<http://www.cbd.int/biosafety/background.shtml>

<http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm>

<http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html>

9.	TBT 1030:INDUSTRIAL BIOTECHNOLOGY	Credits 3

UNIT-I:

MICROBIAL GROWTH KINETICS: An introduction to microbial growth, Different phases of microbial growth, Monods' Growth equation, Factors affecting the microbial growth, Measurement of growth.

UNIT-II:

Enzyme kinetics: Introduction to enzyme catalysis, Michaelis Menten Equation, Types of enzyme inhibition, Enzyme immobilization.

UNIT-III

Bioreactors: Types of bioreactors, Modes of operation, Importance of agitation and aeration, Media optimization and development of seed inoculums for production process.

UNIT-IV

Production of microbial polysaccharides, enzymes, amino acids, antibiotics, organic acids etc.

UNIT-V

Recovery of industrial products, separation, filtration, flocculation, coagulation.

UNIT-VI

Cell disruption techniques: Mechanical and non-mechanical procedures, Centrifugation.

UNIT-VII

Waste water management: Conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic and fermentative bacteria, Eutrophication.

To be offer and decide by other department for this programme.

UNIT-I:

MICROBIAL GROWTH KINETICS: An introduction to microbial growth, Different phases of microbial growth, Monods' Growth equation, Factors affecting the microbial growth, Measurement of growth.

UNIT-II:

Enzyme kinetics: Introduction to enzyme catalysis, Michaelis Menten Equation, Types of enzyme inhibition, Enzyme immobilization.

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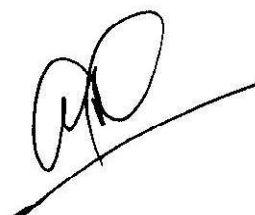
UNIT-VI

Cell disruption techniques: Mechanical and non-mechanical procedures, Centrifugation.

UNIT-VII

Waste water management: Conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic and fermentative bacteria, Eutrophication.

To be offer and decide by other department for this programme.

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BIRLA INSTITUTE OF TECHNOLOGY- MESRA, RANCHI

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

Based on CBCS & OBE model

Recommended scheme of study for M.Tech Programme in Biotechnology

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

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

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

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

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

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

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

Department of Bio- Engineering

B.I.T., Mesra, Ranchi

B.E. Course Structure w.e.f. 2011 Batch

Course No	Course Title	L	T	P	CREDIT
1stSemester					
HU-1101	Technical English	3	0	0	3
PH1201	Physics	3	1	0	4
MA1201	Engg. Mathematics	3	1	0	4
EE2201	Principles of Electrical Engg	3	1	0	4
CH1401	Engg. Chemistry	3	0	0	3
ME1202	Engg. Graphics	1	0	3	3
CS1302	Fundamental of Unix & C Programming	1	0	3	3
PE1202	Workshop Practice	0	0	3	2
PH1202	Physics lab	0	0	3	2
GA1002/ GA1004 GA1006/GA1008	NCC / NSS / PT & Games / C. Arts	0	0	2	1
Total					29

2nd Semester					
EC2001	Principle of Electronics Engg	3	0	0	3
MA2201	Advance Engg Mathematics	3	1	0	4
CH2203	Environmental Science	3	0	0	3
CS2301	Fundamentals of Data Structure	3	1	0	4
ME2001	Principles of Mechanical Engg	3	0	0	3
AM1201	Engineering Mechanics	3	1	0	4
CH1402	Chemistry Lab	0	0	3	2
EE3202//AM2202	Basic Electrical Engg Lab/ Engineering Mechanics Lab	0	0	3	2
EC2002	Basic Electronics Engg Lab	0	0	3	2
CS2302	Data Structure Lab	0	0	3	2
GA2/ 4/6/8	NCC / NSS / PT & Games / C. Arts	0	0	2	1
Total					30

3rd Semester					
BT3023	Cell & Molecular Biology	3	0	0	3
BT3025	Bio-analytical techniques	3	0	0	3
BT3027	Biomolecules& Bioenergetics	3	0	0	3
BT3029	Chemical Engineering I	3	0	0	3
BT3021/HU4001	Biological Science/ Foreign Language	3	0	0	3
AM2202/EE3202/	Engineering Mechanics Lab/Basic Electrical Engg Lab	0	0	3	2
BT3024	Cell &Molecular Biology Lab.	0	0	3	2
BT3026	Bio-analytical techniques Lab.	0	0	3	2
BT3028	Biochemistry Lab.	0	0	3	2
GA3002/4 /6/8	NCC/NSS/PT & Games/ Creative Arts	0	0	2	1
Total					24

4th Semester					
BT4021	Chemical Engineering II	3	1	0	4
BT4023	Microbiology	3	0	0	3
BT4025	Immunology	3	0	0	3
BT4027	Thermodynamics of Chemical & Biological Systems	3	0	0	3
HU4001/ BT3021	Foreign Language/ Biological Science	3	0	0	3
BT4022	Chemical Engineering I Lab.	0	0	3	2
BT4024	Microbiology Lab.	0	0	3	2
BT4026	Immunology Lab.	0	0	3	2
GA4002/4 /6/8	NCC/NSS/PT&Games/ Creative Arts	0	0	2	1
Total					23

Course No	Course Title	L	T	P	CREDIT
<u>5thSemester</u>					
BT5021	Bioprocess Engineering	3	0	0	3
BT5023	Chemical Engineering III	3	1	0	4
BT5025	Functional Genomics and rDNA Technology	3	0	0	3
BT5027	Reaction Engineering	3	0	0	3
	Breadth Subject-I	3	0	0	3
BT5022	Bioprocess Engineering Lab.	0	0	3	2
BT5024	Chemical Engineering Lab. II	0	0	3	2
BT5026	rDNA Tech. Lab	0	0	3	2
Total					22
<u>6th Semester</u>					
BT6021	Bioseparation Engineering	3	0	0	3
BT6023	Plant & Agriculture Biotechnology	3	0	0	3
BT6025	Food & Enzyme Technology	3	0	0	3
BT6027	Process Measurement and Control	3	0	0	3
	Breadth Subject-II	3	0	0	3
BT6022	Bioseparation Engineering Lab.	0	0	3	2
BT6024	Plant Cell Technology Lab.	0	0	3	2
BT6026	Enzyme Technology Lab.	0	0	3	2
Total					21
<u>7th Semester</u>					
BT7021	Biological Waste Management	3	0	0	3
BT7023	Bioreactor and Bioprocess Design	3	0	0	3
	Breadth Subject-III	3	0	0	3
ELECTIVE- I	[DEPT.] (Any one from following)	3	0	0	3
BT7025	Bioenergy				
BT7027	Bioremediation				
BT7029	Pharmaceutical Biotechnology				
BT7031	Mineral Biotechnology				
BT7033	Animal & Stem Cell Technology				
BT7035	IPR, Biosafety & Bioethics				
ELECTIVE- II	[OPEN] (Any one from following)	3	0	0	3
BT7022	Environmental Biotechnology Lab.	0	0	2	2
BT7024	Bioinformatics Lab I	0	0	3	2
BT7050	Dept. Project I	0	0	6	4
Total					23
<u>8th Semester</u>					
BT8021	Biotechnology Management	3	0	0	3
BT8040	Industrial Training (To be evaluated with Dept. Project II)				
BT8050	Dept. Project II	0	0	6	4
Total					7

Total Credits : 29+30+24+23+22+21+23+07=179

3rd Semester

BT3021 Biological Sciences

Module-I

Nature of living things: Definition of life, Miller's experiment, theories and evidences about origin of life, levels of biological organization, classification of living world.

Module-II

Biomolecules: composition of living matter, water, carbohydrates, lipids, proteins, nucleic acids, vitamins and minerals.

Module-III

Biochemistry: Bioenergetics and thermodynamics, biological oxidation-reduction reactions, glycolysis, citric acid cycle, fatty acid metabolism, electron transport chain, aerobic and anaerobic respiration

Module-IV

Molecular organization of cell: Viruses, cellular structure of microorganism, animal and plant, salient features of intracellular organelles, cell division and cell cycle, structure of chromosomes, difference between prokaryotes and eukaryotes.

Module-V

Molecular biology: Structure of DNA and RNA, DNA as genetic material, central dogma of molecular biology, DNA replication, transcription and translation, Introduction to bioinformatics and drug designing.

Module-VI

Enzymology: Mechanism of enzyme action, Lock and key model and induced fit model, active site, MichaelisMenten equation, reversible and irreversible inhibitors, competitive, non-competitive and uncompetitive inhibition.

Module-VII

Techniques in biological sciences: Centrifugation, chromatography, gel electrophoresis, spectroscopy, thermal analysis,.

Books Recommended

1. Purves et al, Life: The Science of Biology
2. R. Dulbecco, The Design of Life.
3. Lehninger A, Principals of Biochemistry
4. Stryer L, Biochemistry
5. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.

BT3023 Cell & Molecular Biology

Module-I

Introduction To The Cell: Evolution of cell, prokaryotic and eukaryotic cell, unicellular and multicellular organisms. Cell Organelles: Cell wall, cell membranes, cytosol, mitochondria, chloroplast, nucleus, ribosome, liposomes, golgi body, endoplasmic reticulum, motility organelles, flagella, pili, cilia, Cell division

Module-II

Cell Signaling: General principles of cell signaling, Signaling via G-Protein linked cell-surface Receptors, Signaling via Enzyme-linked cell-surface Receptors, target cell adaptation

Module-III

DNA structure & Chromosomes: DNA as genetic material, structure of DNA, DNA replication, repetitive DNA, Chromosomal DNA and its packaging,

Module-IV

Genetic organization: Discovery and salient features of genetic code, overlapping genes, organellar genetic code, colinearity of genes and protein, organelle and extranuclear inheritance.

Module-V

Regulation of gene activity: Central dogma, difference in genetic organization of prokaryote and eukaryote, *lac* operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins.

Module-VI

Mutation: General properties and types of mutation, DNA damage and repair, reverse and suppressor mutations, duplications, deletions, inversions and translocations, polyploidy, transposable elements, inborn errors of metabolism.

Module-VII

RNA & Protein: RNA synthesis & RNA processing, Protein synthesis, Posttranslational modifications.

Books Recommended

1. Alberts et al, Molecular Biology of the Cell
2. Lodish et al, Molecular Cell Biology
3. DeRobertis, Cell Biology
4. Harper, The Cell

BT3025 BIOANALYTICAL TECHNIQUES

Module-I

Centrifugation Techniques: Introduction, basic principle of sedimentation, basic idea of types of centrifuges, density gradient centrifugation, preparative centrifugation, analysis of subcellular fractions, & applications of analytical centrifugation.

Module-II

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

Module-III

Chromatographic Techniques – II: (a) Gas Chromatography: Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. (b) HPLC: Principle, components of HPLC system, pumping systems, detectors systems, and its applications; UPLC.

Module-IV

Electrophoresis: (a) General principle, factors affecting electrophoresis – voltage, current, resistance, buffer – composition, concentration, pH. (b) Gel electrophoresis; Types of gels (starch, agarose, polyacrylamide), Idea of electrophoresis unit, preparation of gel, sample application, running the samples, SDS-PAGE - Principle, apparatus and methods, gradient gels, Two dimensional gels, isoelectric focusing.

Module-V

Spectroscopy – I: (a) Spectroscopic Techniques; Introduction, Energy levels and transition of electrons, Types of spectra, Beers Lamberts law, molar and extinction coefficient. (b) Visible and UV Spectrophotometry; Principles, Instrumentation and applications. (c) Spectrofluorimetry; Principle, Stoke's shift, quantum efficiency, instrumentation, & applications

Module-VI

Spectroscopy – II: (a) Atomic & Flame spectrophotometry ; Principles, Instrumentation & applications for flame emission / atomic absorption spectrophotometry and their comparative study; ICP (b) Mass spectrometry; Principles, Instrumentation and applications

Module-VII

Thermal Analysis: Differential scanning calorimetry and differential analysis - Instrumentation, Thermogravimetry, Methodology of Thermogravimetry, differential scanning calorimetry and differential thermal analysis.

Books Recommended:

K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.

Willard and Merrit, Instrumental Methods and Analysis

Ewing GW, Instrumental Methods of Chemical analysis.

BT3027 Biomolecules & Bioenergetics

Module-I

Nucleic Acids: Generalised structural plan of nucleic acids(DNA, RNA), Nucleotides, Nucleosides, features of DNA double helix, phosphodiester bonds, hypochromic effect, different types of DNA

Module-II

Proteins: Structure and properties of 20 amino acids, Zwitterion nature of amino acids in aqueous solution, Abbreviation and classification of 20 amino acids, definition of N-terminal and C-terminal amino acids, basic understanding of primary, secondary, tertiary, quaternary structure of proteins, elementary idea of protein denaturation and loss of biological activity

Module-III

Carbohydrates: Definition, empirical formula, classification into mono, oligo, & polysaccharides, structure of biologically important carbohydrates (D-glucose, D-galactose, D-mannose,), formation of D-maltose, D-sucrose, D-lactose, Polysaccharides such as starch, glycogen, cellulose

Module-IV

Carbohydrate Metabolism: Individual reactions of glycolysis, alcoholic fermentation, gluconeogenesis, Oxidation of Pyruvate to Acetyl CoA, individual reactions of TCA cycle, regulation of TCA cycle

Module-V

Lipids: Definition, general formula of fatty acids, properties of fatty acids, general structure and function of major lipid sub-classes: triacylglycerol, phosphoglycerides, waxes, sterols, beta oxidation pathway, omega oxidation, oxidation of unsaturated fatty acids, biosynthesis of fatty acids

Module-VI

Enzymes: IUB enzyme classification (overview), Lock and key model and induced fit model apoenzyme, holoenzyme, Mechanism of enzyme action by lowering activation energy, concept of active site, MichaelisMenten equation, Effect of temperature, pH and substrate concentration on enzyme action, enzyme turnover number Specific activity

Module-VII

Enzymes Immobilization: Definition, methods of immobilisation -covalent coupling to supports (brief), physical adsorption, entrapment, chemical aggregation, microencapsulation, immobilisation through carbohydrate chains. Effect of pH, temperature, chemical denaturants on immobilised enzymes. Applications of immobilised enzymes (brief)-in medicine, industry

Books Recommended:

Albert Lehninger, Principles of Biochemistry

Lehninger, Nelson, Cox, Principles of Biochemistry

Cohn and Stumpf, Outlines of Biochemistry

LubertStryer, Jeremy M. Berg, John L. Tymoczko, Biochemistry

R.K. Murray, D.K. Granner et al., Harper's Biochemistry

Voet&Voet, Biochemistry

BT3029 CHEMICAL ENGINEERING I

Module-I

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

Module-II

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

Module-III

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

Module-IV

Ideal Gas Law, real gas relationship, vapor pressure, saturation and equilibria.

Module-V

Vapor-liquid equilibria, partial saturation and humidity, condensation and vaporization.

Module-VI

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

Module-VII

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

Books Recommended:

Himmelblau, Basic Principles and Calculations in Chemical Engineering.

Hougen, O.A. and Watson, K.M. Chemical Process Principles (Part I)

BT3024 Cell and Molecular Biology Lab.

1. Microscopy
2. Cell motility and flagellar staining, Photography and videotaping (motility, morphometry)
3. Micrometry: Calibration of stage and ocular micrometer and measurement of the given biological sample.
4. Haemocytometer: calibration and measurement of biological samples.
5. Gram staining, Giemsa, Trypan blue staining.
6. Isolation and purification of genomic DNA from bacteria/plant.
7. Isolation and purification of plasmid DNA.
8. Analysis of DNA by agarose and polyacrylamide gel electrophoresis.
9. Recovery of DNA from gels.
10. Restriction analysis of DNA.

BT3026 Bioanalytical Techniques Lab

1. Gas Chromatography
2. Liquid Chromatography
3. Mass Spectrometry
4. FTIR
5. DSC
6. SEM
7. ICP-OES
8. TGA

BT3028 BIOCHEMISTRY LAB.

1. Introduction to measurements: balances and pipetting Preparation of solutions of given normality and its standardization
2. pH meter: preparation of buffers of different capacity
3. Colorimetry: To determine the dissociation constant of a given indicator colorimetrically and to prepare the buffer solutions in the pH range of 2.2 to 8.0
4. Chemical analysis of water
5. Thin layer chromatography: lipids, mixture of dyes
6. Spectrophotometry: Analysis of glucose, sucrose and ethanol
7. ELISA Reader and spectrophotometer: Estimation of protein by Lowry, Biuret and Bradford methods
8. Enzyme assays
9. Protein estimation.

4th Semester

HU4001 Language

BT4021 Chemical Engineering II

Module-I

Basic Equations of Fluid Flow: 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, angular momentum equation.

Module-II

Flow of Incompressible Fluids: 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 of liquids in thin layers.

Module-III

Flow of Compressible Fluids: Processes of compressible flow, Flow through variable-area conduits, adiabatic frictional flow, isothermal frictional flow, flow past immersed bodies, drag coefficients, stagnation point and stagnation pressure, motion of particles through fluids, hindered settling, fluidization, minimum fluidization velocity, types of fluidization.

Module-IV

Transportation and Metering of Fluids: pipe fittings and valves, positive displacement pumps, centrifugal pumps, head losses in centrifugal pump, blower and compressor, flow measuring devices such as venturimeter, orifice meter, pitot tube and rotameter.

Module-V

Heat transfer by conduction in solids: Fourier's Law, thermal conductivity, Steady state conduction, compound resistance in series, heat flow through a cylinder, one dimensional unsteady state heat conduction.

Module-VI

Heat transfer by convection: 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, filmwise and dropwise condensation.

Module-VII

Radiation heat transfer: 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.

Books Recommended:

1. McCabe, Smith and Harriot, Unit Operation of Chemical Engineering
2. Fox and McDonald, Introduction to fluid mechanics
3. Hollman, Heat transfer, 8th Ed.
4. Foust, Wenzel, Clump, Maus and Andersen, Principles of Unit Operations.
5. Geankoplis, Transport processes and unit operations

BT4023 Microbiology

Module-I

Introduction: History of Microbiology, Methods in Microbiology-Microscopy, Methods of sterilization; culture media, Pure culture methods, Staining of Bacteria, Micrometry, culturing cells and spores, Classification of microorganisms into different groups: Bacteria, Viruses, Fungi, Actinomycetes, Outline of classification of bacteria and fungi

Module-II

Structure of Microorganisms and Microbial Metabolism: Fine structure of bacteria, Archaeobacteria, Mycoplasmas, Mycobacteria, Myxobacteria, Rickettsiae and chlamydiae, structure and classification of Viruses (Bacteriophage, Oncogenic viruses), Growth of Microorganisms, Cell cycles, Population growth, Batch culture, Continuous culture, Synchronous growth, Fed-batch culture.

Module-III

Environmental Microbiology: Distribution of Microbes in Air and water, Allergic disorders by air microflora, air sampling, Microbial components of water, Water treatment, Bacteriological analysis of water. Microbiology of Extreme environments (Methanogens, Halobacteria, Thermoacidophiles), Microbiology of sewage.

Module-IV

Agricultural Microbiology: Parasitism, Commensalism, Symbiosis and related microbial interactions, Rhizosphere and Rhizoplane, Bioinoculants. Beneficial plant-microbial interactions. Microbial Biodeterioration of agricultural products, Mycotoxins, control of microbes and safe storage of agricultural products, RH value, Aw values.

Module-V

Aquatic microbiology: microbiology of sewage, aquatic microorganisms & their interactions, Role of relative humidity (RH) & water availability (Aw) in Microbial interactions

Module-VI

Microbial Biotechnology: Microbes in metal recovery, microbes in paper industries, Microbes as a source in vitamin production. Industrially important micro-organisms, secondary metabolites from micro-organisms.

Module-VII

Medical Microbiology: Diseases caused bacteria, virus, fungi, and protozoans; Fungal diseases (Mycoses), Microbial flora of healthy human host, host – microbe interactions, natural resistance and nonspecific defense mechanisms. Microbial agents of disease

Books Recommended:

Pelczar, Chan and Krieg, Microbiology

Stanier et al, General Microbiology

Rangaswamy et. al. Agriculture Microbiology

Gary Stacey, & Noel T. Keen Plant-Microbe interactions

Effect of Mineral-Organic-Microorganism Interactions on Soil by J. Berthelin, P. M.

Huang, J. M. Bollag, F. Andreux (Plenum Publishing Corporation)

BT4025 Immunology

Module-I

Introduction and history. The immune system, innate and acquired immune system, components of immune system, role of humoral and cell-mediated immunity.

Module-II

Antibodies, the genetic basis of antibody diversity, structure-function, immunoglobulin classes. Polyclonal and Monoclonal antibodies, Catalytic antibodies.

Module-III

Structure and properties of antigens, biological aspects of antibody-antigen interaction.

Module-IV

Identification and measurement of antibodies and antigens, Radial Immuno diffusion, Ouchterlony Double diffusion, Immuno electrophoresis, Radio Immunoassay, ELISA, Western blot, Immunofluorescence. Agglutination and complement

Module-V

Hypersensitivity, Type I, Type II, Type III, Type IV

Module-VI

Major histocompatibility complex, Development of DNA vaccine

Module-VII

Immunological disorders

Books recommended

Essential Immunology Roitt,

Immunology, the immune system in health and disease Jareway et al,

BT4027 Thermodynamics of Chemical & Biological Systems

Module-I

Introduction: Concept of Continuum. Macroscopic approach, Thermodynamics system 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.

Module-II

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, specific heats, Compressibilities and expansion coefficient, First law applied to control volumes (Open System) – Steady & Unsteady flow analysis. Typical applications.

Module-III

Second Law Of Thermodynamics: Second Law, Kelvin-Planck and Clausius statement. Corollaries of Second Law – Reversible and irreversible processes, Thermodynamic (absolute) temperature scale.

Module-IV

Entropy: Inequality of Clausius and concept of Entropy. Entropy change of a system and Control Volume. Principle of increase of Entropy, available and Unavailable Energy.

Module-V

Ideal Gases: Definition, Specific Heats, Entropy change for Flow and Non-Flow processes. Cycles: Simple Vapour power cycles – Carnot, Rankine. Air-Standard Cycles – Joule, Otto, Diesel Cycles. Vapour compression refrigeration cycle.

Module-VI

Gibbs – Duhem equation, phase rule, single component phase equilibria. Thermodynamics of solutions. Ideal and non-ideal solutions. Estimation and determination of activity coefficients

Module-VII

Regular solution theory. Fugacity and properties of mixture. Chemical reaction equilibria. Homogeneous and heterogeneous reaction systems. Thermodynamic analysis of biochemical reactions. Classical and non-equilibrium thermodynamics of biochemical reactions.

Books Recommended:

P.K. Nag, Thermodynamics

Wyllen, Fundamentals of classical thermodynamics.

Denbigh, Principles of chemical equilibria

Dodge, Chemical engineering thermodynamics

Stephanopoulos et al, Metabolic engineering, Principles and Methodologies.

BT4022 Chemical Engineering I Lab.

1. Introduction to Good Laboratory Practice (GLP).
2. Material balance in a chemical reaction by gas flow meter.
3. To calibrate a rotameter and plot correction curves at various pressure heads.
4. To draw the distribution curve for methanol water system using vapor-liquid equilibria set up.
5. To determine the heat of solution by mixing using a calorimeter.
6. To determine the mass flow rate and pressure drop across the venturimeter.
7. To draw the characteristic curve for the flow through venturimeter.
8. To study the flow behavior across the orifice meter and draw the characteristic curves for various inlet pressures.
9. To test the significance of Bernoulli's equation for the energy balance by orifice meter.
10. To study the flow across the various notches.
11. Calculate the velocity of the flow and pressure drop across the pitot tube.
12. To study the fluidization effect and pressure drop in a fluidized bed column.
13. To calculate the pressure drop and superficial velocity of flow in packed bed column.
14. To calculate the pressure drops in various pipes and fitted valves in pipefittings.
15. To study the pattern of flow in free and forced vortex.
16. To calculate the loss of heads in centrifugal pump.

BT4024 Microbiology Lab.

1. Cleanliness, media preparation, sterilization, culturing methods, dilution techniques, and isolation of pure cultures – techniques.
2. Staining techniques in microbiology i) simple staining ii) negative staining iii) positive staining iv) spore staining v) capsule staining and identification.
3. Culture characteristics of microbes, identification of unknown bacteria by biochemical tests.
4. Bacterial growth curve – serial dilution plating and turbidity measurement.
5. Competent cell preparation, replica plating.
6. Extracellular enzymatic activities of microbes, immobilization of *Saccharomyces cerevisiae* and alcohol.
7. Standard qualitative analysis of water.
8. Antibiotic sensitivity test, LD50, Potency of drugs/antibiotics and biotransformations.

BT4026 Immunology Lab

1. Immunodiffusion
2. Immunoelectrophoresis
3. Western blotting
4. Production of monoclonal antibodies and testing,
5. Antigen – Antibody reactions (Widal test, Blood grouping, Rh factor)
6. RBC & WBC count by haemocytometer
7. ELISA

5th Semester

BT5021 Bioprocess Engineering

Module-I

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 behavior, kinetics of product formation.

Module-II

Mass balance and yield concepts: Yield and maintenance coefficients, calculation based on elemental balances, degree of reduction, theoretical predictions of yield coefficients.

Module-III

Enzyme kinetics: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for more complex enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems, brief introduction to large scale enzyme production.

Module-IV

Media and air sterilization: introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters.

Module-V

Agitation and aeration: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_{La}), measurement of k_{La} , power requirement for agitation in gaseous and non gaseous systems.

Module-VI

Operating considerations for bioreactors: Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors:

Module-VII

Analysis of ideal bioreactors: Fed-batch reactors, Enzyme catalysed reactions in CSTRs, CSTR reactors with recycle and wall growth, ideal Plug-flow tubular reactor.

Books Recommended:

Lee, Biochemical Engineering

Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR

Aiba and Humphrey. Biochemical Engineering

Doran, Bioprocess Engineering Principles

Bailey and Ollis, Biochemical Engineering Fundamentals

BT5023 Chemical Engineering III

Module-I

Phase diagram, temperature concentration diagram, enthalpy concentration diagram, Ideal solution, Raoult's Law, relative volatility, azeotropes. Differential distillation, flash vaporization, vacuum and steam distillation

Module-II

Multistage contact operations, characteristics of multistage towers, McCabe Theile Method, reflux, maximum, minimum and optimum reflux, tray efficiency, determination of height and column diameter.

Module-III

Ternary liquid equilibria, triangular graphical representation, concept of theoretical or ideal stages and multistage continuous operation.

Module-IV

Leaching, solid-liquid equilibrium, equipments used in solid-liquid extraction. Single and multiple contact. Overall stage efficiency, graphical determination of number of stages.

Module-V

Description of adsorption and absorption processes and their applications, types of adsorption, nature of adsorbents adsorption equilibria.

Module-VI

Properties and handling of particulate solids, size reduction, screening and particle size distribution.

Module-VII

Drag force and terminal settling velocity, principles of filtration, centrifuges.

Books Recommended:

McCabe, Smith and Harriot, Unit Operations of Chemical Engineering

Foust et al, Principles of Unit Operations

Treybal, R.E. Mass Transfer Operations

Badger and Banchero. Introduction to Chemical Engineering.

BT5025 Functional Genomics and rDNA Technology

Module-I

Creation Of Recombinant Molecules: Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method.

Module-II

Genomic evolution: The world of RNA, ribozyme, Genetics to genomics to functional genomics. Forward and Reverse genetics

Module-III

Methods In Genetic Engineering: Restriction and modifying enzymes, Restriction mapping, Southern blot, Northern blot, Western blot, Polymerase Chain Reaction: Thermostable DNA

Polymerases, PCR technique, Inverse PCR, Nested PCR, RACE PCR, RealTime PCR, Site directed mutagenesis,

Module-IV

DNA sequencing: Sanger, Pyrosequencing and other NGS Whole Genome Sequencing: Strategies used,

Module-V

Post-Transcriptional Gene silencing: RNA interference, antisense RNA, siRNA, MiRNA,

Module-VI

Libraries: Genomic, cDNA, EST, Cot-based, Screening of libraries with DNA probes and with antisera. Large insert genomic libraries and physical mapping Strategies and approaches to genome sequencing

Module-VII

Applications Of Recombinant DNA Technology: Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis.

Books Recommended

Old and Primorose- Gene Manipulation

Alberts et al, Molecular Biology of the Cell

Watson, Recombinant DNA.

BT5027 REACTION ENGINEERING

Module-I

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-II

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-III

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-IV

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, Design of multiple reactions in batch, CSTR and PFR,

Module-V

Energy balance equations: equations for batch, CSTR and PFR and their application to the design of reactors, concepts of non-ideality, residence time distribution of fluids in vessels, models for non-ideal flow.

Module-VI

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, advantages and disadvantages of packed bed and fluidized bed catalytic reactors.

Module-VII

Biochemical reaction systems: enzyme fermentation, Michaelis-Menten kinetics, inhibition by foreign substances, kinetics of competitive and noncompetitive inhibitions, microbial fermentation, batch fermentor and mixed flow fermentor, kinetic expressions of fermentation.

Books Recommended

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

Smith, Chemical Engineering Kinetics

Fogglar, Elements of Chemical Reaction Engineering

BT5022 Bioprocess Engineering Lab.

1. Sterilization of inlet and outlet air filters by steam.
2. *In situ* Sterilization of empty bioreactor.
3. Medium preparation and in situ sterilization of medium in the bioreactor.
4. Study of induction effect of galactosidase enzyme in *E. coli*.
5. Fermentation of ethyl alcohol using *Candida albicans*.
6. Fermentation of citric acid using *Aspergillusniger*
7. Creation of auxotrophic mutants for lysine, valine and other essential amino acids.
8. Designing of fermentation processes for penicillin and 6- APA.
9. Designing of fermentation process for lysine
10. Yeast fermentation to produce ethanol.
11. Fermentation of *Penecilliumcrysogenum* to produce penecillin
12. Determination of volumetric oxygen transfer coefficient (k_{La}) by sulphite oxidation method.
13. Determination of volumetric oxygen transfer coefficient (k_{La}) by dynamic method.

BT5024 Chemical Engineering Lab. II

1. To determine thermal conductivity of metal rod by Searl's apparatus.
2. To determine the thermal conductivity of composite wall of insulating materials.
3. To determine convective heat transfer coefficient by electrically heated vertical pipe by free and forced convection.
4. To determine the emissive power of a gray body kept near a black body.
5. To determine the overall heat transfer coefficient of shell and tube heat exchanger.
6. To determine the overall heat transfer coefficient of double pipe heat exchanger.
7. To calculate the heat loss in a lagged pipe made of various insulating materials.
8. To study the performance and determine the equilibrium relationship in bubble cap distillation column.
9. To separate the solute from one phase to another (aqueous to solvent) phase by liquid-liquid extraction.
10. To study the performance of leaching process by solid-liquid extractor and determine the equilibrium relationship.
11. To determine the loss of weight of naphthalene balls in solid air diffusion apparatus.
12. To determine the coefficient of absorption in packed bed column.
13. To study the performance of membrane separation unit.
14. To study crystal size distribution in a crystallizer.
15. To study the rate of drying in forced draft tray drier coupled with IR balance.
16. To study the performance of an ion exchange unit.

BT5026rDNA Tech. Lab

1. Isolation of RNA
2. Electrophoresis of RNA on denaturing gels.
3. cDNA synthesis
4. PCR technique
5. Cloning & 6. Sequencing

6th Semester

BT6021 Bioseparation Engineering

Module-I

Separation of insoluble products: sedimentation, filtration, centrifugation, coagulation and flocculation.

Module-II

Cell Disruption: Mechanical methods, Non-mechanical methods.

Module-III

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption.

Module-IV

Dialysis, electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultra-filtration and micro-filtration.

Module-V

Chromatography: Adsorption chromatography, Ion- exchange chromatography, gel-filtration chromatography, affinity chromatography, high pressure liquid chromatography, hydrophobic chromatography.

Module-VI

Chromatography scale-up.

Module-VII

Crystallization and drying.

Books Recommended:

M.R. Ladisch, Bioseparations Engineering, Wiley Interscience 2001

Kennedy and Cabral, Recovery processes for biological materials.

Heinemann, Product Recovery in Bioprocess Technology, Butterworth Publication.

BT6023 Plant & Agriculture Biotechnology

Module-I

In Vitro culture: benefits and limitations, Culture media components, role of plant growth regulators, sterilization techniques, aseptic manipulation techniques.

Module-II

Callus Culture: Organogenesis and Embryogenesis, Clonal/Micro Propagation, Somaclonal Variation, Artificial Seeds, Production and Use of Haploids.

Module-III

Suspension Cell Cultures: Cell Cycle Synchronization, Production of Secondary Metabolites and other Plant-Derived Chemicals, Bioreactors, Bio-transformation, Long-term storage of cultures.

Module-IV

Protoplast Culture: Isolation, Purification and Plating; Regeneration, Protoplast Fusion, Somatic Hybrids and Cytoplasmic Hybrids.

Module-V

Genetic Improvement of Plants using different In vitro culture Techniques. Development of crops adaptable to environmental stresses, diseases and pests. Agrobacterium mediated plant transformation and hairy root cultures

Module-VI

Transgenic plants: Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added speciality crops, Use of antisense RNA and other technologies.

Module-VII

Indian Agriculture scenario and policy; Use of nanotechnology in Agricultural sciences; Use of remote sensing in Ag sc; Molecular Breeding and Molecular Assisted Selection; Value addition and sustainable agriculture, terminator technology, golden rice.

Books Recommended:

Dixon and Gonzales, Plant cell culture – a practical approach.

Razdan, An introduction to plant tissue culture.

A. Mizrahi, Biotechnology in agriculture

S. Natesh, Biotechnology in agriculture

BT6025 Food & Enzyme Technology

Module-I

An introduction to the chemical, physical and biochemical properties of foods; proteins, lipids, carbohydrates, vitamins, minerals, pigments. Application of rheology in food system. Food texture studies

Module-II

Discovery, classifications and nomenclature of enzymes and enzyme kinetics, Enzyme isolation & Techniques used in the purification of the enzymes. Enzyme assay, Intracellular localization of enzymes. Isozymes, Multienzyme complex, and multifunctional enzymes, Food enzymes.

Module-III

Introduction to food preservation and food processing; heating, chilling, freezing, dehydration; use of salt, sugar, acid, chemical preservatives, modified atmospheres in food preservation; water relations and chemical and microbial stability of foods.

Module-IV

Fermentations: Beverages, Brewing of beer, wine and distilled liquors Fermented Vegetables, fermented dairy products, oriental fermented foods.

Module-V

Enzyme immobilization, production and application of free and immobilized enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics.

Module-VI

Enzyme memory and mnemonic enzymes. Mechanism and action of chymotrypsin, glyceraldehyde, 3-phosphate dehydrogenase, lysozyme, carboxypeptidase, ribonuclease, aldolase and ribozyme.

Module-VII

Molecular structure and function of enzymes. Physico-chemical characterization of enzymes. Folding and active site formation in enzymes. Stability of enzymes: Enzyme stabilization by selection and genetic engineering, protein engineering, reaction environment rebuilding.

Books Recommended:

G.F. Stewart, Introduction to Food Science and Technology

R.P. Singh and D.R. Heldman, Introduction to Food Engineering, Academic Press.

Godfrey and West, Industrial enzymology

Bommarius, A.S. et al., Biocatalysis: Fundamentals and Application- Wiley Publication

Hans Bisswanger, Enzyme Kinetics- Wiley Publication

BT6027 Process Measurement and Control

Module-I

The general control system, transfer functions, process characteristics.

Module-II

Concept of feed back and feed forward control system, process measurements- temperature, pressure, flow, level, physical properties - density, viscosity, pH, power, rotational speed.

Module-III

Final control element, control valves and their characteristics, the controller, proportional integral, proportional integral derivatives controller, pneumatic and hydraulic controller. Servomotor technology in control.

Module-IV

Control system dynamics: transfer function of first order, second order systems. Response of control loop components to forcing functions. Transfer function of feedback control system. Tests for unstable system.

Module-V

Advanced control systems: multivariable control problem, ratio control, cascade control, computed variable control, feed forward control, override control, adaptive control.

Module-VI

Application of computer control, on line computer control, servomotor technology in control, brief idea about application of dynamic matrix control, predictive control, Fuzzy logic control.

Module-VII

Control of heat exchanger, distillation column, bioreactor control system analysis.

Books Recommended:

Coughanouer and Koppel, Process System analysis and Control

Perry's Chemical Engineers Handbook.

BT6022 Bioseparation Engineering Lab

1. Determination of filter efficiency
2. Harvesting of fermentation broth and its processing for product purification.
3. Solid-liquid separation
4. Liquid-liquid separation
5. Disruption of microbial cells
6. Separation by precipitation through adding salts and solvents.
7. Dialysis
8. Ultrafiltration
9. Vacuum evaporation
10. Drying and crystallization.

BT6024 Plant Cell Technology Lab.

1. Preparation of Culture Media, Sterilization of Culture Media and Explant, Inoculation, Growth Analysis, Subculture.
2. Development and Propagation of Suspension Culture cells.
3. Isolation of protoplasts and plating.
4. Encapsulation of somatic embryos / Suspension Culture cells in Alginate Beads.
5. Agrobacterium mediated transformation.

BT6026 Enzyme Technology Lab

1. Isolation of enzymes from microbial sources.
2. Isolation of enzymes from plant sources.
3. Isolation of intracellular enzymes from microbial sources.
4. Enzyme assay techniques (β -galactosidase, time, temperature, protein concentration)
5. Isozymes and activity staining
6. Determination of different kinetic parameters; K_m , V_{max} , optimum pH,
7. LDH : K_m and V_{max} , Various kinetic plots
8. Determination of activation energy.
9. Ammonium sulphate fractionation.
10. Purification of enzymes using Sephadex and gel filtration column.
11. Down stream processing of enzymes by Micro-filtration and Ultrafiltration
12. Immobilization of enzymes

7th Semester

BT7021 Biological Waste Management

Module-I

Physical, chemical and biological characteristics of waste water, BOD, COD

Module-II

Primary Treatment: Screening, Grit Chamber, removal of oil and grease.

Module-III

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,

Module-IV

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

Module-V

Tertiary Treatment :Effluent disposal and reuse.

Module-VI

Solid waste management,

Module-VII

Designing aspects of Wastewater treatment plant

Books Recommended:

Metcalf and Eddy Inc., Waste water engineering

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

BT7023 Bioreactor and Bioprocess Design

Module-I

Design considerations for designing bioreactors: oxygen transfer, heat transfer, rheology, mixing.

Module-II

Study of anaerobic & aerobic processes: Ethanol production, Acetone-Butanol production, citric acid production and penicillin production

Module-III

Reactors with non-ideal mixing: Mixing time in agitated tanks, Residence time distributions, Models for non-ideal reactors

Module-IV

Scale up and scale down concepts,

Module-V

Mechanical fittings in a bioreactor: vessel, agitation system materials, welds, finish, valves, piping and valves for biotechnology, special requirements of utilities and cleaning of production plants.

Module-VI

Instrumentation and control of bioprocesses: Physical and chemical sensors for the medium and gases, online sensors for cell properties, off-line analytical methods; Biosensors.

Module-VII

Calculation for designing a bioreactor.

Books Recommended

Coulson, Richardson, Sinnott, An introduction to chemical engineering design, Pergamon Press.

Lydersen, D'Elia, Nelson, Bioprocess engineering: Systems and equipment.

Bailey and Ollis, Biochemical Engineering Fundamentals.

ELECTIVE- I [DEPT] (Any one from following)

BT7025Bioenergy

Module-I

Chemistry & Biochemistry of Biomass: Types of biomass (e.g. wood waste, forestry residues, agricultural residues, organic municipal solid waste); Composition of lignocellulose (lignin, hemicellulose, cellulose); energy crops; chemical pretreatment; enzymatic pretreatment.

Module-II

BioDiesel: Sources and processing of biodiesel (fatty acid methyl ester); Sources and characteristics of lipids for use as biodiesel. Economics and environmental issues of biodiesel; Components and operation of a bio-diesel processing system; Standards for biodiesel quality.

Module-III

BioEthanol& other Alcohols: Production of Bioethanol by yeast and bacteria; Substrate range and ethanol tolerance; Yield of ethanol production from sugars. Production of methanol and butanol; Technologies for hydrolysis and fermentation of lignocellulosic biomass for the production of alcohols.

Module-IV

BioMethane&BioHydrogen: Formation of biomethane or biogas from landfill and manure. anaerobic digestion; methanogenesis, rates of methane formation; and one and two stage fermentation. Biohydrogen synthesizing microorganisms and its production; Biohydrogen production rates; Production of hydrogen from waste water.

Module-V

Bio-Electricity: Current generation by microorganisms, microbial fuel cells (MFC) for current generation, choice of anode and cathode, Mediator and mediator less MFC, factors influencing the current intensity, simultaneous electricity generation and waste treatment (SEGAWT), aerobic, anaerobic and mixed processes for current generation, kinetics of substrate utilization and electricity generation microbial fuel cell battery.

Module-VI

Direct Biomass Combustion & Co-Firing Technologies: Aanalysis of biomass direct combustion, and co-firing in power plants with high biomass-to-fossil fuel ratios. Fixed-bed, fluidized bed, and dust combustion; Feedstock and plant design optimization, emissions, ash deposition and corrosion control, slagging and fouling problems.

Module-VII

Policies and Future R&D of Biofuels & Bioenergy: Evaluation of current and future R&D needs; legal framework to support sustainable development and increased use of biofuels; government policies and programs with regard to biofuels and investment opportunities worldwide.

Books Recommended:

Kennedy, et al 1985, Cellulose and its derivatives, chemistry, biochemistry and applications, Halsted Press, New York, 1985, 551 pp.

Bard, A. J., and L. R. Faulkner. 2001. Electrochemical methods fundamentals and applications, 2nd ed. John Wiley and Sons, New York, NY

Greg Pahl, 2005, Biodiesel, Chelsea Green Publishing Co

Richard L. Bechtold, 1997. Alternative Fuels Guidebook, SAE International

BT7027 Bioremediation

Module-I

Introduction,

Module-II

Environmental site assessments, microbial ecology of contaminated sites,

Module-III

Predictive models for efficacy of bioremediation, rates and dynamics of bioremediation,

Module-IV

Microorganisms involved in the biodegradation of organic compounds, heavy metals, bioconversion and removal of metals and radionuclides, adaptation:

Module-V

Dynamics of genes, enzyme activities and populations,

Module-VI

Phytoremediation processes, plants involved and their mechanisms in bioremediation,

Module-VII

Protein engineering for improved biodegradation of recalcitrant pollutants.

Books Recommended:

Wild, Varfolomeyev and Scozzafava. Perspective in Bioremediation: Technologies for Environmental Improvement

Singh and Ward Applied Bioremediation and phytoremediation Springer

BT7029 Pharmaceutical Biotechnology

Module-I

Genomics and its impact on medicine. Molecular medicine (Introduction only)

Module-II

Rational drug design,

Module-III

Gene testing, pharmacogenomics.

Module-IV

Principles of monoclonal antibodies, monoclonal antibodies in disease detection and treatment,

Module-V

Cancer oncogenes, tumor suppressor genes, growth factors.

Module-VI

Genetic diseases and DNA based diagnosis of genetic diseases. gene therapy,

Module-VII

Development of genetically engineered pharmaceuticals.

Books Recommended:

Maulik and Patel, Molecular Biotechnology – Therapeutic applications and strategies.

Zito, Pharmaceutical Biotechnology.

BT7031 Mineral Biotechnology

Module-I

Metal Microbe Interaction: Extracellular complexation, extracellular precipitation of metal, Metal resistance in soil bacteria

Module-II

Metal extraction and recovery by microorganisms, Biosorption of metals, biosorption Kinetics, Metal recovery process

Module-III

Biogeotechnology; Bioleaching: low grade technology, high grade technology, bioleaching of gold, copper, uranium, Mechanism of bioleaching, Microbiology of leaching

Module-IV

Biomineralization: bacterial biomineralization, multicellular biomineralization, microbiologically induced corrosion

Module-V

Coal: Nature, structure and types, Bioprocessing of coal, clean coal technology, desulphurization of coal, biological conversion of coal to organic chemicals

Module-VI

Bioreactor design for mineral bioprocessing

Module-VII

Environmental control and mine site remediation, Acid mine drainage: chemistry and control

Books Recommended:

S.K. Kawatra, Mineral Biotechnology.

BT7033 Animal & Stem Cell Technology

Module-I

Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures.

Module-II

Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence, cell-cell communication, cell senescence.

Module-III

Cell Culture Lines: Definition, development and maintenance, cloning of cell lines, cell synchronization viral sensitivity of cell lines, cell line preservation and characterization, stem cell lines.

Module-IV

General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explantation technique.

Module-V

Organ Culture: Methods, behavior of organ explants and utility of organ culture, whole embryo culture.

Module-VI

Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection.

Module-VII

Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, Cloning for production of transgenic animals, cloning for conservation.

Books Recommended:

Freshney, Animal cell culture – a practical approach

N. Jenkins, Animal Cell Biotechnology: methods and protocols.

BT7035 IPR, Biosafety and Bioethics

ELECTIVE- II[OPEN: To be offered by other depts]

BT7022 ENVIRONMENTAL BIOTECHNOLOGY LAB

1. Physico-chemical and biological characterization of wastewater.
2. Determination of total solids, total dissolved solids, total suspended solids, volatile solids, fixed solids/ash content and moisture content in solid waste and wastewater.
3. Determination of MLVSS.
4. Determination of sludge volume index and food to microorganisms.
5. Determination of Kjeldahl nitrogen, nitrate and nitrite nitrogen.
6. Determination of inorganic phosphates by Technicon analyzer.
7. Determination of organic carbon,
8. Determination of various metals present in waste and wastewater samples.
9. Determination of BOD of wastewater samples.
10. Determination of COD of wastewater samples.
11. Enumeration of contaminating pathogenic organisms.
12. Various sampling techniques for collecting air samples.

BT7024 Bioinformatics Lab I

Exercise based on bioinformatics course.

BT7050 Dept. Project I

8th Semester

BT8021 Biotechnology Management

Module-I

Introduction to Biotechnology Management: Introduction to Biotechnology Management, Designing a Manuscript, Grant Experimental Protocols and Experimental Methods, Selection of a Biotechnology company. Setting up of a Unit, Laboratory Administration of a unit, Collaborations, Inventories and Inspections, Personnel, Recruitment, Hiring, Mentoring, Promoting and Terminating.

Module-II

Biostatistics: Pure and Applied Research, Types of Research, (Experimental, Causal, Exploratory, Conclusive, Descriptive), Data Interpretation and Tabulation, Measures of Central Tendency - Mean Arithmetic's, Harmonic and Geometric Median and Mode; Measures of Dispersion - Standard Deviation and Standard Error; Correlation Coefficient, Simple Linear Regression, Basic Idea of Significance Test, Hypothesis Test. Level of Significance, T test, 'Chi' Square and Goodness of Fit Graphics. Bioprocess Development; Instruments and Biotechnological Products, Innovation of Biotechnological Products.

Module-III

Biotechnology Marketing: Marketing of Products, Brand Imaging, Market segmentation, Marketing Application, Cost and Benefit Analysis, Quality Standardization, Advertising and Sales Strategy of Biomedical Products. Implication of Marketing Strategy in Biotechnological Industries.

Module-IV

Manufacturing and Materials Management Ensuring Biosafety: Bio-safety regulations Good laboratory practices, Good manufacturing practices in industry. Storage and disposal of hazardous wastes, Radioactive Materials, Pathogenic Strains. GMO's and their Release in Environment Experimental Protocol Approvals - Levels of Containment-Environmental Aspects of Biotech Applications. Importance of Logistics to Biotechnological Products, Supply Chain Management of Biotechnological Products: an Overview. Reprocessing of Bioformulations.

Module-V

Globalization and Biotechnology: Global Landscape of Pharmaceutical and Biotechnological Industries, Indian Biotechnological and Pharmaceutical Industries and Biotechnology Industry, Management of Biotechnology for Global Sustenance.

Module-VI

Biosafety and Legal Aspects: Environmental Aspects to Biotechnology, Legal Implication to Pharmaceutical and Biotechnology, Safety Management in Biotechnological and Pharmaceutical Industry.

Module-VII

Case Studies of Biotechnological and Pharmaceutical Industries.

Books Recommended:

Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.

Molecular Cloning : A laboratory manual Vol. I - III by Sambrook et al., (2001) Cold Spring Harbor Laboratory

Essentials of management – Koontz and Odonell

Cost Accounting: Horngren.

Marketing Management: Analysis, Planning and Control - Philip Kotler

Research Methodology – By C. R. Kothari (Vikash Publishing).

BT8040 Industrial Training (To be evaluated with Dept. Project II)

BT8050 Dept. Project II

8th Semester

BT8021 Biotechnology Management

Module-I

Introduction to Biotechnology Management: Introduction to Biotechnology Management, Designing a Manuscript, Grant Experimental Protocols and Experimental Methods, Selection of a Biotechnology company. Setting up of a Unit, Laboratory Administration of a unit, Collaborations, Inventories and Inspections, Personnel, Recruitment, Hiring, Mentoring, Promoting and Terminating.

Module-II

Biostatistics: Pure and Applied Research, Types of Research, (Experimental, Causal, Exploratory, Conclusive, Descriptive), Data Interpretation and Tabulation, Measures of Central Tendency - Mean Arithmetic's, Harmonic and Geometric Median and Mode; Measures of Dispersion - Standard Deviation and Standard Error; Correlation Coefficient, Simple Linear Regression, Basic Idea of Significance Test, Hypothesis Test. Level of Significance, T test, 'Chi' Square and Goodness of Fit Graphics. Bioprocess Development; Instruments and Biotechnological Products, Innovation of Biotechnological Products.

Module-III

Biotechnology Marketing: Marketing of Products, Brand Imaging, Market segmentation, Marketing Application, Cost and Benefit Analysis, Quality Standardization, Advertising and Sales Strategy of Biomedical Products. Implication of Marketing Strategy in Biotechnological Industries.

Module-IV

Manufacturing and Materials Management Ensuring Biosafety: Bio-safety regulations Good laboratory practices, Good manufacturing practices in industry. Storage and disposal of hazardous wastes, Radioactive Materials, Pathogenic Strains. GMO's and their Release in Environment Experimental Protocol Approvals - Levels of Containment-Environmental Aspects of Biotech Applications. Importance of Logistics to Biotechnological Products, Supply Chain Management of Biotechnological Products: an Overview. Reprocessing of Bioformulations.

Module-V

Globalization and Biotechnology: Global Landscape of Pharmaceutical and Biotechnological Industries, Indian Biotechnological and Pharmaceutical Industries and Biotechnology Industry, Management of Biotechnology for Global Sustenance.

Module-VI

Biosafety and Legal Aspects: Environmental Aspects to Biotechnology, Legal Implication to Pharmaceutical and Biotechnology, Safety Management in Biotechnological and Pharmaceutical Industry.

Module-VII

Case Studies of Biotechnological and Pharmaceutical Industries.

Books Recommended:

Beier, F.K., Crespi, R.S. and Straus, T. Biotechnology and Patent protection-Oxford and IBH Publishing Co. New Delhi.

Molecular Cloning : A laboratory manual Vol. I - III by Sambrook et al., (2001) Cold Spring Harbor Laboratory

Essentials of management – Koontz and Odonell

Cost Accounting: Horngren.

Marketing Management: Analysis, Planning and Control - Philip Kotler

Research Methodology – By C. R. Kothari (Vikash Publishing).

BT8040 Industrial Training (To be evaluated with Dept. Project II)

BT8050 Dept. Project II



CBCS SYLLABUS

FOR

M.Sc. BIOTECHNOLOGY

(w.e.f. MO-2018 Batch)



DEPARTMENT OF BIO-ENGINEERING

BIRLA INSTITUTE OF TECHNOLOGY

MESRA, RANCHI – 835 215



Department of Bio- Engineering

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

Institute Vision

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

Institute Mission

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

Department Vision

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

Department Mission

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

M. Sc. (Biotechnology)

Programme Educational Objectives (PEOs)

PEO1	Students will gain necessary knowledge and develop specialized skills in the different areas of Biotechnology.
PEO2	Students will think critically and creatively about the use of biotechnology to address local and global problems.
PEO3	Students will be able to implement the scientific skills for development of industrial applications and entrepreneurship.

Program Outcomes (POs)

PO1	Ability to carry out research /investigation independently in specialized area of Biotechnology.
PO2	Ability to write and present a substantial technical report/document.
PO3	Able to demonstrate a degree of mastery in the area of biotechnology to enable them in collaborative and multidisciplinary research.
PO4	Recognise the need for continuous learning and will prepare oneself to create, select, learn and apply appropriate techniques, resources, and modern instrumentation to solve complex biotechnological activities with an understanding of the limitations.
PO5	Demonstrate knowledge of biotechnology and management principles and apply to manage projects efficiently and economically with intellectual integrity and ethics for sustainable development of society.

COURSE INFORMATION SHEET

Course code: BT401

Course title: MOLECULAR CELL BIOLOGY

Pre-requisite(s): Basics of Cell Biology

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Recapitulate the previous knowledge of cell biology and to establish thorough understanding of various cell structure and function at molecular level.
2.	Provide a thorough understanding of the various molecular biology concepts in study of cell biology and to study the different tools and techniques used to study the biology of cell at molecular level.
3.	Provide students with a deep insight about the motility of the cell with emphasis on the molecular motors, cell adhesions, molecular biology involved in the movement process involved in movement of Cilia and Flagella.
4.	Teach our students to have a concrete knowledge about cell to cell communication in animals as well as plants and to study about the basis of the interaction as well as the genes involved in it.
5.	Acquire in-depth knowledge of the molecular events involved in cell division which includes mitosis, meiosis, cell cycle and its regulation. Including. To provide wider and global perspective of cell cycle regulation and cancer, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes:

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

CO1	Apply knowledge of cell biology and molecular Biology in various cellular functions, inculcate a knowledge of various issues related to molecular cell biology, the application and research involved in functioning of the different cell organelles.
CO2	Design and analyze the experiments related with the different molecules involved in cell biology and use of the various techniques in the molecular cell biology to study the kinetics and rationale behind each phenomenon.
CO3	Identify, formulate, and solve problems arisen due to the inefficient functioning of the various life processes like cell to cell communication, cell cycle regulation, movement processes of a cell or system.
CO4	Use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyze data, and interpret results

Syllabus

Module I: Cell Basics- Structure of prokaryotic and eukaryotic cells, membranes and cellular compartments, Structure, function and organization of all cell organelles. Biomembrane structure: Membrane carbohydrates and their roles in cell-cell recognition, Transmembrane: Transport of Ions and Small Molecules, Moving Proteins into Membranes and Organelles: Intracellular Vesicular Traffic, Secretion, and Endocytosis. Neurotransmission and regulation, Overview about genes in various cell organelles.

(8L)

Module II: Cell Chemistry and Biosynthesis, Shape, Structure and Function of Nucleic acid, Proteins. Energy Conversion: Mitochondria and Chloroplasts, Fundamentals of Molecular Biology, chromatin packing, Manipulating Proteins, DNA, and RNA, Microscopy, Hemocytometry, Centrifugation, Freeze Fracture technique, Patch clamp method, FRAP etc.

(8L)

Module III: Self assembly and structure of cytoskeleton filaments, Cytoskeleton filaments regulation by cells, molecular motors, cilia, and flagella of prokaryotes and eukaryotes. Cell-Cell and cell matrix adhesion; Extracellular Matrix, Plant cell wall, Cell junctions, plasmodesmata, gap junctions, desmosomes and tight junction, Overview about genes involved in cell motility.

(8L)

Module IV: General principles of cell communication, signal transduction pathways, signaling through G-protein linked cell surface receptors, signaling through enzyme linked cell surface receptors, signaling pathways that depend on regulated proteolysis. Signaling Pathways that Control Gene Expression, plant growth factors and hormones-auxins, gibberellins, cytokines, Host parasite interaction, Overview about genes involved in cell-cell interaction.

(8L)

Module V: Overview of the cell cycle control system, components of the cell cycle, cell cycle progression, intracellular control of the cell cycle events, extracellular control of cell division, cell growth, and apoptosis. Cell differentiation in plants and animals including terminal cell differentiation, Role of Oncogenes, Tumor suppressor genes, hormones and growth factors in cell transformation and etiology of cancer, Overview about genes involved in cell cycle regulation. Cell cycle synchronization.

(8L)

Books recommended:

TEXT BOOK

1. Molecular biology of the gene by Watson et. Al (5th edition) ISBN: 8177581813
2. Molecular biology of the cell by Bruce Albert et al (4th edition) ISBN: 815332181

REFERENCE BOOK

1. Genes VII by Benjamin Lewin, Oxford University Press ISBN: 019879276X
2. Molecular Cell Biology, by Harvey Lodish, Matthew P. Scott, P Matsudaira, J Darnell, L Zipursky, Chris A. Kaiser, A Berk, M Krieger, publisher: W. H. Freeman; 5th edition, ISBN: 0716743663

Course Evaluation:

Individual assignment, Presentation, Theory (Quiz and End semester) examinations

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

Design of real-time research projects.

POs met through Gaps in the Syllabus: PO2, PO3, PO5

Topics beyond syllabus/Advanced topics/Design:

Design optimization for molecular cell biology projects.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO2, PO3, PO4, PO5.

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT402

Course title: METABOLISM & BIOENERGETICS

Pre-requisite(s): Nil

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Give basic knowledge about catabolism, anabolism, regulation of metabolism and pathway analysis.
2.	Acquire knowledge and understanding of how enzymes and metabolites in living system work to produce energy and synthesizing different biomolecules.
3.	Extend comprehensive knowledge about biochemical pathways involved in intermediary metabolism of carbohydrate, protein, lipid and nucleic acid.
4.	Gain knowledge about the thermodynamic aspects of energetics in living system.

Course Outcomes

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

CO1	Demonstrate an understanding of carbohydrate, protein, lipid and nucleic acid metabolism.
CO2	Distinguish between different metabolic processes and their impact in metabolism of biomolecules.
CO3	Select particular metabolic pathway involved in carbohydrate, protein and fat related metabolic issues
CO4	Apply and analyse the knowledge related to bioenergetics in living system.

Syllabus

Module 1: Introduction to Metabolism: Catabolism, anabolism, metabolic classifications of organisms, metabolic strategies and regulation, methods employed to study metabolism and pathway analysis, Integration of metabolic pathways. (8L)

Module 2: Carbohydrate Metabolism: Glycolysis, Citric acid cycle, Gluconeogenesis, Glycogenesis, Glycogenolysis, Hexose monophosphate shunt, uronic acid pathway, Galactose metabolism, Fructose metabolism, aminosugar and mucopolysaccharides metabolism, and their integration. (8L)

Module 3: Lipid Metabolism: Lipid profile, degradation and biosynthesis and regulation of fatty acids, Metabolism and regulation of membrane lipids, Metabolism, regulation and fate of cholesterol. (8L)

Module 4: Protein and Nucleic Acid Metabolism: Metabolism and regulation of amino acid, Metabolism and regulation of ammonia as well as urea cycle, Metabolism and regulation of nucleotides. (8L)

Module 5: Bioenergetics/Thermodynamics: Laws of thermodynamics, Concept of free energy, entropy, enthalpy and their relationship, Application of free energy function, Integration of metabolic pathways of energy metabolism. (8L)

Books Recommended:

TEXT BOOKS

1. Geoffrey L. Zubey, Biochemistry, Fourth Edition: Wm.C. Brown Publishers, 1998
2. U. Satyanarayana and U. Chakrapani: Biochemistry
3. Biochemistry by Robert Roskoski. W.B. Saunders, Philadelphia, ISBN 0-7216-5174-7

REFERENCE BOOK

1. D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed. New York.
2. Biochemistry 5th Revised edition by Lubert Stryer, Jeremy M. Berg, John L. Tymoczko (ISBN: 8601300395166)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT403

Course title: APPLIED MICROBIOLOGY

Pre-requisite(s):

Co- requisite(s):

Credits: 2 L:3 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Establish an understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	Describe different aspects of microbial nutrition and growth
3.	Describe microbial interactions and their significance in environment
4.	Describe microbial interactions and their significance in agriculture, food and pharmaceuticals
5.	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.	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 community

Course Outcomes:

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

CO1	Identify microbiological techniques, the defining characteristics of the major groups of microorganisms and apply to study microbial phylogeny
CO2	Classify the nutritional types of microorganisms and measure microbial growth
CO3	Evaluate how microorganisms interact with the environment in beneficial or detrimental ways
CO4	Assess impact of plant- microbe interaction on agriculture in both beneficial and detrimental ways. Identify industrially important microbes
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 effective communicate with both specialist and non-specialist audiences/community

Syllabus

Module I: Techniques in Microbiology & Microbial Diversity: Microscopy, Staining in Microbiology, sterilization, Pure culture Methods, Culture Media and its types, Micrometry, Air Sampling, Waste water analysis, Measurement of Microbial Growth, Types of microorganisms, Methods of identification of microorganisms (8L)

Module II: Microbial Nutrition and Growth: Nutritional and Growth Factors requirement of microorganisms, Nutritional Types of Microorganisms, Uptake of Nutrition, Microbial Growth, Influence of Environmental Factors of Growth, Batch Culture, Continuous Culture, Synchronous Growth, Fed-batch Culture. Control of microbial growth by physical and chemical agents (8L)

Module III: Environmental Microbiology: Distribution of Microbes in Air and water, Allergic disorders by air microflora, air sampling, Water treatment, Bacteriological analysis of water, Bioleaching, Bioremediation (8L)

Module IV: Agricultural Microbiology and Industrial Microbiology: Plant-microbes interactions, Microbial Biodeterioration of agricultural products, control of microbes and safe storage of agricultural products, Biofertilizers, industrially important micro-organisms, secondary metabolites from micro-organisms, Microbiology of foods, Single cell Protein (8L)

Module V: Medical Microbiology: Diseases caused bacteria, virus, fungi, and protozoans; Fungal diseases, Host parasite interaction-recognition and entry process of different pathogens in plants and animals, Toxins produced, Vaccines, Anti-microbial agents, Antibiotics and disinfectants, National Immunization Programme (8L)

Books recommended:

Text books:

1. Willey, Sherwood, Woolvertan, Prescott/Harley/Klein's Microbiology, 7th Ed., TMH, 2007
2. Tortora, Microbiology: an Introduction, 12th Ed., Pearson, 2016
3. Frazier and Westhoff, Food Microbiology, 4th Ed., TMH, 1995

Reference books:

1. Pelczar, Chan and Krieg, Microbiology, 5th Ed., McGraw Hill, 1985
2. Stanier, General Microbiology, 1st Ed., MacMillan, 1958

Course Evaluation:

Individual assignment, Presentation, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	1	3	3	1
CO2	1	2	3	3	1
CO3	2	3	3	2	2
CO4	2	3	3	2	2
CO5	2	3	3	2	2
CO6	3	3	3	3	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3 and CD6
CO2	CD1, CD2, CD3 and CD6
CO3	CD1, CD2, CD4, and CD6
CO4	CD1, CD2, CD4, CD5 and CD6
CO5	CD1, CD2, CD4, and CD6
CO6	CD1, CD2, CD3, CD4, CD5 and CD6

COURSE INFORMATION SHEET

Course code: BT404

Course title: MATHEMATICS AND STATISTICS FOR BIOLOGISTS

Pre-requisite(s):

Co- requisite(s): Nil

Credits: 3 L: 03 T:0 P: 0

Class schedule per week: 03

Class: M. Sc.

Semester / Level: I

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

1.	Work on basic science as well as biotech industry in multidisciplinary teams and independently.
2.	Learn various tools to design, conduct, mathematical & statistical analysis new experiments, measurements and interpreting experimental data from biological system and addressing the challenges associated with the interaction between living systems and non-living materials.
3.	Grab the knowledge theory of basic mathematical & statistical tools used in biological research/ biotechnology industry and research lab (Probability, Sampling Theory and Test of Hypothesis).
4.	Enable the students to understand the principle and application of Differential Calculus, Differential Equations and various Computational Techniques
5.	A Master's degree in this field prepares a student for careers in biotech research in different domains including industry.

Course Outcomes

After the completion of this course, students will gain:

CO1	An ability to apply knowledge of mathematics and statistics to design and conduct experiments, as well as to analyze and interpret data related to domain of biology.
CO2	An ability to design a system, component, or process to performing research in biological system and addressing the challenges associated with the interaction between living systems and non -living materials. 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 basic mathematical & statistical tools used in biological research/ biotechnology in industry and research lab.
CO4	An ability to understand the principle and application of Differential Calculus, Differential Equations and various Computational Techniques
CO5	A Master's degree in this field prepares a student for careers in higher education, as well as in pharmaceutical and biotechnology industries in government and private agencies. An ability to function in multidisciplinary teams. An ability to identify, formulate, and solve Science/Engineering problems.

Syllabus

Module 1: Linear Algebra and Probability: Set Theory, Matrices, Scalars, Vectors, Determinants, Eigen values & vectors, Variance (Discrete, Continuous), Mean, Median, Mode, Standard Deviation. (8L)

Module 2: Sampling Theory and Test of Hypothesis: Introduction to sampling theory, Probability Distribution (Binomial, Poisson & Normal), Type I & Type II error, one tailed & two tailed test, Level of significance, t-test and chi-square test. (8L)

Module 3: Differential Calculus: Limit and continuity, Introduction to differentiation, Finding maxima and minima, Introduction to integration, Application to Biological Sciences. (8L)

Module 4: Differential Equations: Differential equations, HIV dynamics, Ludeking & Piret Model, Protein folding. (8L)

Module 5: Use of Computational Techniques: Application of Computational tools (MATLAB): case study, Plotting of equations, Statistical optimization tools, (8L)

Books recommended:

TEXT BOOK

1. Fundamentals of Mathematics by William M. Setek, Jr. And Michael A. Gallo, Prentice Hall, ISBN- 0 -13 -778341 -8.
2. Basic Technical Mathematics with Calculus by Allyn J. Washington, Addison- Wesley Publishing Company

REFERENCE BOOK

1. Mathematical Methods in Physical Sciences by Mary L. Boas, Wiley India, ISBN- 9/8-81-265-0810-5
2. Mathematical Biology I &II by J.D. Murray, Springer- Verlag Texts

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

POs met through Gaps in the Syllabus

Topics beyond syllabus/Advanced topics/Design

POs met through Topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD3 and CD6
CO2	CD1, CD2, CD3 and CD6
CO3	CD1, CD2, CD4, and CD6
CO4	CD1, CD2, CD4, CD5 and CD6
CO5	CD1, CD2, CD4, and CD6
CO6	CD1, CD2, CD3, CD4, CD5 and CD6

COURSE INFORMATION SHEET

Course code: BT 405

Course title: CELL BIOLOGY AND BIOCHEMISTRY LAB

Pre-requisite(s):

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc.

Semester / Level: 1/4

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students:

1.	To recapitulate the previous knowledge of cell biology and biochemistry in order to design experiments to analyze some of the established facts about cell biology and biochemistry. To 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.
2.	To provide quantitative analysis of the macromolecules in the given sample and analyse the results.
3.	To provide students with a deep insight of the various biochemical reactions and cellular processes through quantitative and qualitative analysis of the samples provided.
4.	To inculcate in our students a concrete knowledge of reactions involved in the biological processes and to understand the rationale behind them. Identify, formulate, and solve problems arising due to the inefficient functioning of the systems in life sciences.
5.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcomes:

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

CO1	To apply knowledge of cell biology and biochemistry in various cellular functions, inculcate a knowledge of various issues related to life processes and the application of research involved in functioning of the different cell organelles and accessories.
CO2	To design and analyze the experiments related with the different molecules involved in cell biology and use of the various techniques in the molecular cell biology to study the kinetics and rationale behind each phenomenon.
CO3	To identify, formulate, and solve problems arisen due to the inefficient functioning of the various life processes and anatomical aspects of plants and animals.
CO4	To use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a research project, collect and analyze data, and interpret results

Syllabus

List of Experiments

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

Books recommended:

1. **Gerczei Fernandez, Timea / Pattison, Scott:** Biochemistry laboratory manual for undergraduates: An inquiry-based approach, SCIENDO, Open Access PDF ISBN 978-3-11-041133-1
2. **Arun Rastogi:** Laboratory Manual in Biochemistry, Anmol Publisher (2011) ISBN-10: 8126144998

Course Evaluation:

Lab (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT406

Course title: MICROBIOLOGY LAB

Pre-requisite(s):

Co- requisite(s): BT403

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To establish an understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
2.	To describe different aspects of microbial nutrition and growth
3.	To describe microbial interactions and their significance in environment
4.	To describe microbial interactions and their significance in agriculture, food and pharmaceuticals
5.	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 community

Course Outcomes:

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

CO1	Identify microbiological techniques, the defining characteristics of the major groups of microorganisms and apply to study microbial phylogeny
CO2	Classify the methods to measure microbial growth
CO3	Evaluate how microorganisms interact with the environment in beneficial or detrimental ways
CO4	Identify industrially important microbes
CO5	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effectively communicate with both specialist and non-specialist audiences/community

Syllabus

List of Experiments

1. Cleanliness, media preparation, culturing methods, dilution techniques, and isolation of pure cultures by different techniques
2. Staining techniques in microbiology
3. Biochemical tests for identification of unknown microorganisms.
4. Evaluation of disinfectants and antiseptics, evaluation of sterilization methods.
5. Bacterial growth curve.
6. Standard qualitative analysis of water.
7. Micrometry
8. Antibiotic sensitivity test; Isolation of antibiotic resistant bacteria from waste / sewage water.

Book Recommended:

TEXT BOOK

1. James G. Cappuccino and Natalie Sherman: Microbiology: A Laboratory Manual, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., 2005

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY
METHOD

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

COURSE INFORMATION SHEET

Course code: BT407

Course title: GENOMICS

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc.

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To understand about differences between prokaryotic and eukaryotic genomes as well as forward and reverse genetics.
2.	To learn about techniques used in genomics, genome sequencing, annotation, database development as well as their applications.
3.	To impart knowledge about the advances in structural and functional aspect of newly sequenced genome
4.	To understand the use of genomics in the crop improvement, drug discovery, value added crops as well as development of recombinant protein.

Course Outcomes:

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

CO1	Explain the detailed characteristics of prokaryotes and eukaryotes genome as well as application of forward and reverse genetics.
CO2	Get knowledge and design the experiments using various techniques of genome sequencing as well proper organization of generated biological data
CO3	Apply structural and functional genomics approaches on newly sequenced genome for functional characterization of genes.
CO4	Develop capacity to pin point the strategies used for crop improvement and development of drug, recombinant proteins or value added crop.

Syllabus

Module 1: Genomic Evolution & Organization: RNA world hypothesis, Genetics to Genomics, Forward and reverse genetics. Eukaryotic and prokaryotic genomes, Chromosome structure and function, Chromatin re-modeling/organization, DNA as genetic material, Central dogma of molecular biology. (8L)

Module2: Genome Sequencing: Overview of conventional and new sequencing technologies, Strategies used in whole genome sequencing, NGS technologies, RNAseq, Genome annotation, Candidate gene discovery and data mining, Transcription factor, Development of databases and their uses, Genome mapping by genetic and physical technique, Comparative genomics and SNP analysis. (8L)

Module-3: Techniques for Genomics: Restriction and modifying enzymes, Various blotting techniques, PCR techniques, RT-PCR, qPCR, Digital PCR, Site directed mutagenesis, Genomic and cDNA libraries, Screening of libraries, DNA microarray, Antisense RNA, RNA interference, TALEN, CRISPR-Cas9. (8L)

Module 4: Genome Initiatives: Structural and functional genomics, Advances in human genome, Advances in buffalo genome, Advances in Arabidopsis genome, Advances in rice genome, Advances in wheat genome, Advances in tomato genome, Advances in sorghum genome, Advances in peanut genome etc. (8L)

Module 5:

Application of Genomics: Genomics in gene function analysis, Genomics in plant and animal breeding and improvement, Genomics in drug discovery, Genomics in value-added crops, Genomics in recombinant protein etc. (8L)

Book Recommended:

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.

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.

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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT408

Course title: Genomics Lab

Pre-requisite(s): NIL

Co- requisite(s):BT 407

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc.

Semester / Level: 1/4

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students:

1.	To recapitulate the previous knowledge of Molecular Biology and biochemistry to design experiments.
2.	To use the techniques and skills necessary for estimation and quantification of DNA and their further analysis.
3.	To use the techniques and skills necessary for estimation and quantification of RNA and their further analysis.
4.	Use of modern tools for analysis of Nucleic acids and their further analysis.
5.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcomes:

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

CO1	To handle DNA and its manipulation
CO2	To handle DNA and its manipulation
CO3	Hands on and gain expertise in handling routine laboratory equipment used in Genomics lab
CO4	To use modern tools for analysis of Nucleic acids and their further analysis. Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Syllabus

List of Experiments

1. Isolation and purification of DNA.
2. Separation of DNA by agarose gel electrophoresis.
3. Isolation and purification of RNA.
4. Electrophoresis of RNA on denaturing gels.
5. Spectrophotometric estimation of DNA and RNA.
6. Preparation cDNA.
7. PCR amplification of gene of interest.
8. Real Time PCR/ PCR based comparative gene expression analysis of different tissue samples.
9. Visualization/analysis of data.

Text book

1. 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.

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.

Course Evaluation:

Lab (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT409

Course title: INDUSTRIAL BIOTECHNOLOGY

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Know about principle of growth, importance of maintaining the cultures, techniques used for enhancing the yield and role of various factors on the growth of biological strains, significance of medium constituents on production process in liquid cultivation
2.	Design criteria for fermenter and operation of bioreactor, solid state fermentation and calculation of yield
3.	Learn the processes of primary and secondary metabolite production with certain examples and case study, production of enzymes and therapeutics from biological systems
4.	Gain knowledge about the application of living systems for energy production, in bioremediation and biotransformation with certain examples

Course Outcomes:

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

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process
CO2	State the significance of application of fermentation in production of primary and secondary metabolites, production of important enzymes, solve the mass balance of production process
CO3	Collect the proficient knowledge of living systems in the energy production, utilization of waste to commercially important compounds and bioremediation process

Syllabus

Module 1: Technology of Microbial growth and Maintenance: Principles of Microbial growth, Methods to increase yield of microbes, Strain preservation, maintenance and improvement, Microbial culture selection for high yield potential, Physico-chemical parameters for microbial growth

[8 L]

Module 2: Bioreactor / Fermenter: Types & operation of Bioreactors, Introduction to Batch, Fed-batch and Continuous culture systems, Limitations of bioreactors, Stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, advantages & disadvantages of solid substrate & liquid fermentations.

[8 L]

Module 3: Production of Primary and Secondary Metabolites: A brief outline of processes for the production of some commercially important primary metabolites (e.g. citric acid, lactic acid, acetic acid etc., glutamic acid, aspartic acid etc.) and alcohols (ethanol, butanol), Production processes for various classes of secondary metabolites such as beta-lactams (penicillin, cephalosporin etc.), aminoglycosides (streptomycin) macrolides (erythromycin), and Vitamins

[8 L]

Module 4: Production of Enzymes and other Bioproducts: Production of industrial enzymes such as proteases, amylases, lipases, Production of biopesticides, biofertilisers, biopreservatives (Nisin), Single cell protein, Production of recombinant proteins with therapeutic and diagnostic applications, Production of vaccines and monoclonal antibodies, Products of bioproducts from plant and animal cell culture.

[8 L]

Module 5: Bioconversions and Bioremediation: Biomining and bioleaching of ores, Ethanol, methane and Hydrogen from biomass, Production of Biodiesel, Algal Biofuel, Bioremediation of oil spills, Wastewater treatment, Removal of heavy Metals, Microbial degradation of pesticides and aromatics compound.

[8 L]

Text Books:

1. Industrial Biotechnology, Isha Book, India (2006)
2. Biotechnology for Agro-Industrial Residues Utilisation, Springer, Netherland (2009)
3. Basic Industrial Biotechnology, New Age International Pvt Ltd, India (2012)

Reference Books:

1. Industrial Biotechnology: Sustainable Production and Bioresource Utilization, CRC Presss, Taylor and Francis (2017)
2. Industrial Biotechnology: Microorganisms, John Wiley and Sons (2017)

Course Evaluation:

Individual assignment, Presentation, Theory (Quiz and End semester) examinations

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

Design of real-time industrial projects: NA

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects: NA

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT410

Course title: INDUSTRIAL BIOTECHNOLOGY LAB

Pre-requisite(s):

Co- requisite(s): None

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Know about principle of growth, importance of maintaining the cultures, techniques used for enhancing the yield and role of various factors on the growth of biological strains, significance of medium constituents on production process in liquid cultivation
2.	Design criteria for fermenter and operation of bioreactor, solid state fermentation and calculation of yield
3.	Learn the processes of primary and secondary metabolite production with certain examples and case study, production of enzymes and therapeutics from biological systems
4.	Gain knowledge about the application of living systems for energy production, in bioremediation and biotransformation with certain examples

Course Outcomes:

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

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process
CO2	State the significance of application of fermentation in production of primary and secondary metabolites, production of important enzymes, solve the mass balance of production process
CO3	Collect the proficient knowledge of living systems in the energy production, utilization of waste to commercially important compounds and bioremediation process

Syllabus

List of Experiments

1. Isolation of proteolytic enzymes from soil sample
2. Production of baker's yeast and inoculums preparation
3. Production of citric acid by SSF
4. Preparation of standard plot of protein
5. Preparation of standard plot of sugar
6. Growth of microorganism and yield calculation
7. Immobilization of whole cell by entrapment
8. Kinetic study of enzyme

Books Recommended:

TEXT BOOKS:

1. Doran, Bioprocess Engineering Principles, Academic Press, 1995
2. Bailey and Ollis, Biochemical Engineering Fundamentals, 1986

Reference Books:

1. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
2. Industrial Biotechnology: Microorganisms, John Wiley and Sons (2017)

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: NA

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects: NA

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY
METHOD**

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

COURSE INFORMATION SHEET

Course code: BT411

Course title: MOLECULAR PLANT PHYSIOLOGY

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To understand about photosynthesis and detailed mechanism involved in the CO ₂ fixation by plants
2.	To learn about techniques used in genetic modification for increased plant biomass
3.	To impart knowledge about the structure and functionality of chloroplast protein and their encoding genes as well as plant hormones
4.	To develop novel protein using various recent approaches and increase crop production under adverse condition

Course Outcomes:

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

CO1	explain the detailed characteristics of chloroplast and mechanism of photosynthesis
CO2	engineer photorespiration as well as apply other approaches to increase plant biomass
CO3	gain the proficient knowledge about structure and functionality chloroplast protein and encoding genes as well as hormonal response on plants
CO4	develop capacity to pin point the suitable strategies in developing stress resistance plants and increasing crop productivity

Syllabus

Module 1: Photosynthesis: Anatomy of chloroplasts, photosynthetic pigments, Structure of photosystems I and II and their coding genes, Molecular oxygen evolving complex, Photolysis of water; mechanisms of electron transport; Calvin cycle and its light/dark regulation. RuBisCO activities, C3, C4 and CAM pathways. (8L)

Module 2: Photorespiration and Respiration: Photorespiration, Gross and net photosynthesis, Glycolysis, Citric acid cycle; Electron transport and ATP synthesis; Pentose phosphate pathway, Mitochondrial ATP synthase, Engineering or genetic modification of photorespiration (8L)

Module 3: Photomorphogenesis: Molecular structure of phytochrome, Photoconversion, Nuclear translocation of Pfr and modification of gene expression, Family of PHY genes and multiplicity of responses. Structure and function of Cryptochromes. Photoperiodism and biological clocks. (8L)

Module 4: Stress Physiology: Biotic and abiotic stress responses in plants, Characteristic features of stress responsive genes, stomatal functions and transpiration, Physiological process affected by stresses and resistance mechanisms, Molecular responses to various stress perception, expression of regulatory genes and significance of gene products. Development of stress resistance plant. (8L)

Module 5: Plant Hormones: Overview about various plant hormones, Molecular mechanism of plant hormones action, Hormone receptors and signal transduction, Gene expressions at developmental stages and stresses, Phytohormone signalling in plant defense mechanism, Cross-talk and molecular aspect of growth and development processes. (8L)

Book Recommended:

TEXT BOOK:

1. Plant Physiology, 5th Edition by Lincoln Taiz and Eduardo Zeiger, Sinauer Associate (2010). ISBN: 978-0878938667
2. Plant Physiology, 4th Edition, by Salisbury F. B. and Ross C. W. (2004), Wadsworth Publisher, ISBN: 9788131501658, 8131501655

REFERENCE BOOK:

1. The Molecular Life of Plants by Russell L. Jones, Helen Ougham, Howard Thomas, Susan Waaland (2012) Wiley-Blackwell. ISBN: 978-0-470-87011-2
2. Plant Hormones under Challenging Environmental Factors by Ahammed, Golam Jalal, Yu, Jing-Quan (2016) ISBN 978-94-017-7758-2

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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT412

Course title: MOLECULAR PLANT PHYSIOLOGY LAB

Pre-requisite(s):

Co- requisite(s): None

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To understand about photosynthesis and detailed mechanism involved in the CO ₂ fixation by plants
2.	To learn about techniques used in genetic modification for increased plant biomass
3.	To impart knowledge about the structure and functionality of chloroplast protein and their encoding genes as well as plant hormones
4.	To develop novel protein using various recent approaches and increase crop production under adverse condition

Course Outcomes:

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

CO1	Explain the detailed characteristics of chloroplast and mechanism of photosynthesis
CO2	Engineer photorespiration as well as apply other approaches to increase plant biomass
CO3	Gain the proficient knowledge about structure and functionality chloroplast protein and encoding genes as well as hormonal response on plants
CO4	Develop capacity to pin point the suitable strategies in developing stress resistance plants and increasing crop productivity

Syllabus

List of Experiments

1. Quantification of pigment content in leaves.
2. Comparison of photosynthetic pigment content under different stresses.
3. Observation of absorption spectra of photosynthetic pigment.
4. Isolation of chloroplast
5. Isolation and purification of RNA.
6. Quantification of RNA AND preparation cDNA.
7. PCR amplification of gene of interest.
8. Real Time PCR/ PCR based comparative gene expression analysis of different tissue samples.
9. Visualization/analysis of data.

Recommended Books:

Text Book

1. Experiments in Plant Physiology: A Laboratory Manual by Dayananda Bajracharya, Narosa Publishing House (1999), ISBN: 978-8173193101.
2. Research Experiences in Plant Physiology: A Laboratory Manual by Moore, T.C. (1974) ISBN 978-3-642-96168-7.

Reference book:

1. Plant Physiology, 5th Edition by Lincoln Taiz and Eduardo Zeiger, Sinauer Associate (2010). ISBN: 978-0878938667
2. Plant Physiology, 4th Edition, by Salisbury F. B. and Ross C. W. (2004), Wadsworth Publisher, ISBN: 9788131501658, 8131501655
3. The Molecular Life of Plants by Russell L. Jones, Helen Ougham, Howard Thomas, Susan Waaland (2012) Wiley-Blackwell. ISBN: 978-0-470-87011-2
4. Plant Hormones under Challenging Environmental Factors by Ahammed, Golam Jalal, Yu, Jing-Quan (2016) ISBN 978-94-017-7758-2
5. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

1. Conducting presentations in group and writing reports.
2. Giving assignments to the students on some relevant topics.

POs met through Gaps in the Syllabus: PO2, PO3

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: PO1, PO4

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT414

Course title: BIOSIGNAL ACQUISITION SYSTEM LAB.

Pre-requisite(s):

Co- requisite(s): BT413

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: I/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

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

Syllabus

List of Experiments

1. To study and calculate body mass index and its correlation with human health.
2. To study different types of electrodes and sensors used in bio-potential recordings.
3. To study and measure non-invasive blood pressure using sphygmomanometer.
4. To analyse the characteristics of different types of electrolytic medium between electrode and body.
5. To record and analyse bipolar electrocardiogram.
6. To record and analyse surface electromyogram.
7. To record and analyse vertical and horizontal eye ball activity.
8. To study and analyse electrical and mechanical cardiac activities using phonocardiography.
9. To record biopolar and monopolar electroencephalogram and analyse delta, theta, alpha and beta bands.
10. To study and analyse haemodynamic activity using pulse plethysmography.
11. To record and analyse electrodermal activity or galvanic skin response.
12. To study and perform lie detector test.

Books Recommended:

TEXT BOOKS:

1. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown, Pearson , 2001
2. Handbook of Biomedical Instrumentation by R. S. Khandpur, Tata McGraw-Hill Education, 1994
3. Biomedical Instrumentation and Measurement by L. Cromwell et al., Prentice Hall

REFERENCE BOOKS:

1. Biomedical Digital Signal Processing by W. J. Tompkins, Prentice Hall; Har/Dskt edition (March 2, 1993)
2. Biomedical Signal Processing: Principles and Techniques by D C Reddy., McGraw-Hill Education (India) Ltd.

Course Evaluation:

Written test, viva and performance examinations

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

3. Conducting presentations in group and writing reports.
4. Giving assignments to the students on some relevant topics.

POs met through Gaps in the Syllabus: PO2, PO3

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: PO1, PO4

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT415

Course title: MOLECULAR BIOLOGY & rDNA TECHNOLOGY

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes

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

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

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

Syllabus

Module 1: Genetic Organization: Central dogma of molecular biology, structure of DNA, DNA replication, DNA damage and repair, repetitive DNA, kinetics of DNA renaturation. Discovery and salient features of genetic code, organellar genetic code. RNA synthesis, RNA processing and RNA editing, Protein synthesis and Posttranslational modifications of proteins, collinearity of genes and protein 8L

Module 2: Gene Regulation: difference in genetic organization of prokaryote and eukaryote, *lac* operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins, Small Double stranded RNAs and RNA interference, Epigenetics 8L

Module 3: Methods in Genetic Engineering: Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique and its variants, Quantitative Real-Time PCR, Site directed mutagenesis, Restriction and modifying enzymes 8L

Module 4: Creation of Recombinant Molecules and Libraries: Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method. Genomic, cDNA, EST and Large insert genomic libraries, Strategies and approaches to genome sequencing, Overview of Enzymatic DNA sequencing, NGS, Assembly and annotation of DNA sequences. 8L

Module 5: Applications of Recombinant DNA Technology: Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis, Golden rice, Terminator technology, Safety guidelines of recombinant DNA research. 8L

Books recommended:

1. Old and Primorose- Gene Manipulation, Wiley, 2002
2. Alberts et al, Molecular Biology of the Cell, W. W. Norton & Company; Sixth edition (November 18, 2014)
3. Watson, Recombinant DNA., Scientific American Books
4. Lodish et al, Molecular Cell Biology., Freeman and Co., 2013

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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 SWAYAM

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY
METHOD**

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

COURSE INFORMATION SHEET

Course code: BT416

Course title: ENZYME AND BIOPROCESS TECHNOLOGY

Pre-requisite(s): BT 409

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess, kinetics of product formation
2.	Aware about significance of enzyme catalysis, production of enzyme at large scale and stability related issues, media constituents, formulations and sterilization, types of sterilizes and role of filters on sterilization
3.	Expand the knowledge on agitation of media, stirring mechanism, kinetics of oxygen supply, and requirement of power during the process
4.	Identify the reactors applicability as per the process requirement, understand mode of reactor operation and significance of solid state fermentation

Course Outcomes:

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

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process and sterilization
CO2	State the significance of application of process technology on enzyme production, enzyme kinetics, solve the mass balance of production process, learn the process of oxygen transfer rate, agitation systems
CO3	Collect the proficient knowledge of design of fermenter and operation of fermentation process, methods of translation of laboratory data to pilot scale process

Syllabus

Module 1: Cell growth and bio-product formation kinetics: Growth patterns and kinetics in batch culture, quantification of cell growth, effect of environmental factors on microbial growth, kinetics of product formation, growth, non-growth associated products, yield concepts and mass balance. 8L

Module 2: Enzyme kinetics: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, effect of pH, temperature, concentration of substrate on enzyme catalysis, stability of enzymes, methods of immobilization, immobilized enzyme reactors, diffusional limitations in immobilized enzyme systems, large scale enzyme production, case study for manufacture of commercial enzymes and applications. 8L

Module 3: Media and air sterilization: Importance of media on growth, introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters. 8L

Module 4: Agitation and aeration: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_{La}), measurement of k_{La} , power requirement for agitation in gaseous and non gaseous systems. 8L

Module 5: Bioreactor Selection and Design: Selection criteria for bioreactor, body construction of fermenter and its components, solid state and submerged fermentation, design aspects of bubble column bioreactor, air-lift fermenter, plug-flow and packed bed bioreactor, scaling up of bioreactor, Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors. 8L

Books Recommended:

TEXT BOOKS:

- 1: Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
- 2: Aiba and Humphrey. Biochemical Engineering, Academic Press (1965)
- 3: Doran, Bioprocess Engineering Principles, Academic Press, 2012
- 4: Enzyme by Palmer (2001); Horwood publishing series, Elsevier

REFERENCE BOOKS:

- 1: Bailey and Ollis, Biochemical Engineering Fundamentals, TATA-McGraw Hill, 2nd ed.
- 2: Lee, Biochemical Engineering, Prentice Hall, 1992.

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: NA
POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects: NA

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT417

Course title: BIOINFORMATICS

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	State and comprehend the fundamental concepts of database system and its architecture, importance of biological database in the current time
2.	Extend comprehensive knowledge about data mining and Big data analysis and its complexity.
3.	Demonstrate concept about Biological problem solving, regarding to sequence alignment and Genome editing, motif finding with the help of specific algorithms
4.	Gain knowledge about the techniques for molecular modelling and drug designing

Course Outcomes:

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

CO1	Explain the theoretical knowledge of database system and algorithms.
CO2	Analyze and discuss the results in light of molecular biological knowledge (sequence alignment and phylogenetic tree plot)
CO3	Collect the proficient knowledge to solve biological system- a multi-disciplinary problem
CO4	Develop the key skills of molecular modeling techniques currently practiced in any pharmaceutical research and development unit.

Syllabus

Module I: Major Information Resources & Databases in Bioinformatics: Information Resources: NCBI, EBI, ExPasy, Entrez, Derived (Secondary) Databases of Sequences, Different Bio-sequence File Formats.

(8L)

Module II: Sequence Analysis: Homology, Gap Penalty, Scoring matrices (PAM, BLOSUM), Dot matrix method, Dynamic programming using Needleman-Wunsch algorithm, Scoring methods of MSA (Sum of Pair), BLAST and FASTA.

(8L)

Module III: Phylogenetic Analysis: Molecular Phylogenetics: Basics, molecular clock, Substitution Models of evolution, Tree reconstruction methods (Distance based).

(8L)

Module IV: Molecular Modeling and Molecular Docking: Structure alignment: superimposition and RMSD calculations, DALI, Classification of 3-D structures of proteins, SCOP, CATH, Structure Prediction of Protein Structure (Chou-Fasman), Homology modelling.

(8L)

Module V: Applications of Bioinformatics: Cheminformatics, Bigdata analysis, Microarray - Data analysis, Theory and Algorithms, motif analysis and presentation.

(8L)

Books recommended:

TEXT BOOK

1. Bioinformatics: Sequence and Genome Analysis, David W Mount, Cold Spring Harbor Laboratory Press, New York.
2. Bioinformatics: a practical guide to the analysis of genes and proteins, Baxevanis A., Ouellette F.B.F., John Wiley and Sons, New York.

REFERENCE BOOK

1. Guidebook on Molecular Modeling In Drug Design, J. G. Vinter, Mark Gardner (Editor), J. G. Vinter (Editor), CRC Press (May 1994) ISBN: 0849377722
2. Fundamental Concepts of Bioinformatics, Dan E Krane, Michael L Raymer, Benjamin- Cummings Pub Co (ISBN 0805346333)

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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

CO	PO1	PO2	PO3	PO4	PO5
CO1	1	2	2	2	2
CO2	1	-	2	3	3
CO3	3	1	2	2	-
CO4	4	2	-	2	2

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT418

Course title: ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	The primary objectives of this course are to develop the skills to understand the theory and practice of bioanalytical techniques
2.	Additionally, an overview of the instruments used in isolation and separation of molecules will also be provided.
3.	To provide scientific understanding of analytical techniques and detail interpretation of results.
4.	This will enable the students to understand all subjects of Biotechnology as these tools and techniques will be used therein.

Course Outcomes:

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

CO1	Familiarity with working principals, tools and techniques of analytical techniques.
CO2	Apprehend the functioning, maintenance and safety aspects of the apparatus used in a Biotechnology lab.
CO3	Assimilate the principles and applications of centrifuge, electrophoresis, chromatography and spectroscopy in research and related experiments.
CO4	To understand the strengths, limitations and creative use of techniques for problem solving.

Syllabus

Module 1: Centrifugation Techniques and Imaging: Principle, instrument and application of steady state sedimentation, density gradient centrifugation, ultracentrifugation, Atomic Force Microscopy, Scanning & Transmission Electron Microscopy. 8L

Module 2: 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. 8L

Module 3: Chromatographic Techniques: Principles, design and application of column chromatography, partition and adsorption chromatography, Affinity Chromatography; Ion Exchange Chromatography, Gas Chromatography, HPLC. 8L

Module 4: Spectroscopy -I: Beers Lamberts law, Principles, Instrumentation and applications of Visible and UV Spectrophotometry; Spectrofluorimetry (FRET); FTIR, NMR spectroscopy. 8L

Module 5: 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. 8L

Books Recommended:

TEXT BOOK

1. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry. Cambridge University Press, 1994

REFERENCE BOOK

1. Willard and Merrit, Instrumental Methods and Analysis, CBS Publishers & Distributors; 7th edition (December 1, 2004)
2. Ewing GW, Instrumental Methods of Chemical analysis. "McGraw-Hill Inc.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

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

Course Delivery Methods

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

CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

Course code: BT419

Course title: ENZYME AND BIOPROCESS TECHNOLOGY LAB

Pre-requisite(s):

Co- requisite(s): None

Credits: 2 L:3 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Understand the process of microbial growth and synthesis of bioproducts, methods of measurements of growth and mass balance of the bioprocess, kinetics of product formation
2.	Aware about significance of enzyme catalysis, production of enzyme at large scale and stability related issues, media constituents, formulations and sterilization, types of sterilizers and role of filters on sterilization
3.	Expand the knowledge on agitation of media, stirring mechanism, kinetics of oxygen supply, and requirement of power during the process
4.	Identify the reactors applicability as per the process requirement, understand mode of reactor operation and significance of solid state fermentation

Course Outcomes:

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

CO1	Understand the growth kinetics, Monod equation and explain the role of various factors affecting the process of growth. They will also be able to define the media for submerged and solid-state fermentation process and sterilization
CO2	State the significance of application of process technology on enzyme production, enzyme kinetics, solve the mass balance of production process, learn the process of oxygen transfer rate, agitation systems
CO3	Collect the proficient knowledge of design of fermenter and operation of fermentation process, methods of translation of laboratory data to pilot scale process

Syllabus

List of Experiments

1. Bacterial growth kinetics.
2. Calculation of specific growth rate.
3. Sterilization of inlet and outlet air filters by steam.
4. *In situ* Sterilization of empty bioreactor.
5. Medium preparation and sterilization of medium.
6. Designing of fermentation process for enzyme production
7. Designing of fermentation process for ethanol production
8. Designing of fermentation process for organic acid production.
9. K_{La} determination using non-fermentative and fermentative methods
10. effect of mixing and agitation rate on KLa ,
11. Screening of enzyme producing microorganism viz. cellulase, hemicellulase, asparaginase, lipase etc.
12. Determination of kinetic parameters in enzyme catalysed reactions.
13. Sterilization of inlet and outlet air filters by steam.

Books Recommended:

TEXT BOOKS:

- 1: Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
- 2: Aiba and Humphrey. Biochemical Engineering, Academic Press, New York
- 3: Doran, Bioprocess Engineering Principles, Academic Press, 2013.
- 4: Enzyme by Palmer (2001); Horwood publishing series

REFERENCE BOOKS:

- 1: Bailey and Ollis, Biochemical Engineering Fundamentals, McGraw-Hill, 1986.
- 2: Lee, Biochemical Engineering, Prentice Hall, 1992

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: NA

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

Design optimization for industrial projects: NA

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

COs	PO1	PO2	PO3	PO4	PO5
CO1	1	-	2	3	-
CO2	1	1	3	2	3
CO3	3	2	-	2	3

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

Course code: BT420

Course title: GENOMICS & rDNA TECHNOLOGY LAB

Pre-requisite(s):

Co- requisite(s): None

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes

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

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

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

Syllabus

List of Experiments

1. Isolation and purification of DNA.
2. Isolation and purification of RNA.
3. Isolation and purification of plasmid DNA.
4. Spectrophotometric estimation of DNA and RNA.
5. Separation of DNA by agarose gel electrophoresis.
6. Electrophoresis of RNA on denaturing gels.
7. PCR Amplification, Agarose gel electrophoresis and elution of DNA bands from gel.
8. T/A cloning of eluted DNA in plasmids.
9. Bacterial transformation and selection of transformants.
10. Validation of transformants using PCR technique.

Books recommended:

TEXT BOOK

1. Old and Primorose- Gene Manipulation, Oxford; Seventh edition (2006)
2. Alberts et al, Molecular Biology of the Cell, Garland Science; 5 edition (2008)

REFERENCE BOOK

1. Watson, Recombinant DNA. W. H. Freeman; Second Edition edition (1992)
2. Lodish et al, Molecular Cell Biology. W. H. Freeman; 6th edition (2007)

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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 SWAYAM

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

**MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY
METHOD**

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

COURSE INFORMATION SHEET

Course code: BT421

Course title: PROTEOMICS

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To organize protein in four structural levels: Primary, Secondary, Tertiary and Quaternary, study on post translational modifications, structural determination and folding.
2.	Extend comprehensive knowledge about characterization, tools and techniques in determination of abundance of protein in particular tissue and its quantification.
3.	Obtain information about atomic mass, amino acid sequence and basic physical and chemical properties of protein, the technology used in determining these informations.
4.	Gain knowledge about the production of industrial important proteins and enzymes, designing new proteins with special functions and storage and use of proteomics database.

Course Outcomes:

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

CO1	Handle a proteins and its characterization.
CO2	Know the principles of proteome quantification.
CO3	Demonstrate how various types of mass spectrometers (e.g. Orbitrap, triple-quad, Q-TOF) can be used for proteome quantification, structure determination of proteins by various methods.
CO4	Use software tools to analyse various quantitative proteomic data types, Principles of statistical analysis of proteomic data, how quantitative proteomics can be applied in biology, clinical research and drug discovery and designing novel proteins.

Syllabus

Module I: Protein Basics: Proteomics basics, Forces that determine protein structure and physicochemical properties, Mechanisms of protein folding, Molten globule structure, Characterization of folding pathways. 8L

Module II: Protein isolation and profiling: Method for protein isolation and purification, Profiling by Native-PAGE, SDS-PAGE, 2-D/IEF SDS-PAGE, staining and de-staining, imaging and analysis of 1-D and 2-D gels. 8L

Module III: Protein characterization: Protein sequencing using various methods, Protein identification by mass spectrometry, Determination of post translation modification, Proteomics tools and databases, Thermal, enzymatic, physical, pressure, solvents, interactions effect on protein, Application of DSC, Protein denaturation, aggregation and gelation. 8L

Module IV: Protein structure: Background and basic principles of various spectroscopic techniques used for protein structure determination, Absorption and fluorescence, Circular dichroism, FT-Raman, FT-IR, NMR, Protein crystallization and X-ray crystallography, MALLS. 8L

Module V: Development of novel proteins: Basic concepts for design of a new protein, Site directed mutagenesis for specific protein function, Specific examples of novel engineered proteins. 8L

Book Recommended:

TEXT BOOK

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

REFERENCE BOOKS:

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

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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT422

Course title: PROTEOMICS LAB

Pre-requisite(s): NIL

Co- requisite(s):BT 421

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc.

Semester / Level: 1/4

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students:

1.	To recapitulate the previous knowledge of Molecular Biology and biochemistry to design experiments.
2.	To use the techniques and skills necessary for Isolation and estimation of Protein and their further analysis.
3.	To use the techniques and skills necessary for quantification of Proteins and their further analysis.
4.	Use of modern tools for analysis of Proteins.
5.	Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Course Outcomes:

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

CO1	To handle Protein and its Estimation
CO2	To quantify the protein
CO3	Hands on and gain expertise in handling routine laboratory equipment used in Proteomics lab
CO4	To use modern tools for analysis of Protein and their further analysis. Independently execute a laboratory experiment using the standard methods and techniques in molecular biology, with the appropriate analysis and interpretation of results obtained.

Syllabus

List of the Experiments

1. Introduction about various instruments used in the lab.
2. Solution preparation given normality/concentration and its standardization.
3. Buffer preparation of different pH capacity.
4. Extraction of protein from the given plant sample.
5. Estimation of protein concentration of the protein extract by suitable method.
6. Enzyme assays.
7. Partial purification of protein by precipitation and subsequent dissolving in the buffer.
8. Assay of a suitable/selected enzyme using spectrophotometer.
9. Separation of protein using SDS-PAGE.
10. Protein profiling using 2-D IEF/ SDS-PAGE.
11. Visualization of protein spot and analysis.

Book Recommended:

TEXT BOOK

1. Proteins and Proteomics: A Laboratory Manual by Richard Simpson, Cold Spring Harbor laboratory Press, U.S.; Lab Manual edition (13 December 2002) ISBN-10: 0879695544
2. Plant Proteomics: Jozef Samaj (Author), Jay J Thelen (Author) Springer India Private Limited (2007) ISBN-10: 8132205162

REFERENCE BOOK

1. Principles of Proteomics 14 Oct 2013 by Richard Twyman Garland Science; 2 edition (14 October 2013) ISBN-10: 0815344724

Course Evaluation:

Lab (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design:

POs met through topics beyond syllabus/Advanced topics/Design

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT423
Course title: ANIMAL BIOTECHNOLOGY
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc.
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To impart the knowledge on basic tissue culture techniques;
2.	to apply the state of art knowledge of subject for the production of transgenic animals and production modern drug delivery or vaccination methods.
3.	To become familiarize with the ethical practices in animal biotechnology

Course Outcomes:

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

CO1	To demonstrate foundational knowledge of Cell culture techniques and competence in laboratory techniques. Student can set up a tissue culture lab to carry out research.
CO2	To acquire knowledge in animal cloning and its applications by various methods.
CO3	To acquire adequate knowledge in the use of genetically modified organisms and its beneficial uses.
CO4	To gain more insights into the ethical issues and regulatory affairs.

Syllabus

Module 1: Techniques in Animal Tissue Culture: Primary and secondary cell culture and maintenance; Embryonic fibroblast isolation and culture; measurement of cell viability/toxicity, cell separation, development, cryopreservation and transport of germplasm; Embryonic and pluripotent stem cell culture and sorting. 8L

Module 2: Organ and Histotypic Cultures: cell synchronization, characterization and recent development; In Vitro fertilization and embryo transfer; Tissue engineering; Organ Culture. 8L

Module 3:

Transgenesis: Gene propagation methods; Use of cloning and expression vectors, Adeno viral vectors and Baculoviruses; Genetically engineered proteins, vaccines, hormones etc. produced in the host; newly emerging transgenic tools. 8L

Module 4:

Medical Molecular Biology: Designer/transgenic animals as different disease models comparable to human system; Gene therapy and its utilization; Cloning and xenotransplantation. 8L

Module 5:

Animal Genetic Engineering: Chemical and electrochemical gene transfection methods - microinjection, viral and other methods of gene transfection; application of transgenic animals for pharmaceutical and therapeutic purposes; Ethical issues related to animal biotechnology. 8L

Books Recommended:

TEXT BOOKS:

- 1: Animal Cell biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.
- 2: Animal Biotechnology: Murray Moo-Young (1989), Pergamon Press, Oxford.

REFERENCE BOOKS:

- 1: Masters, J. R.W., Animal Cell Culture, Oxford (2000) 3rd ed.
- 2: Srivatsa AK, Singh RK, Yadhav MP. Animal biotechnology

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT424
Course title: ANIMAL CELL TECHNOLOGY LAB
Pre-requisite(s):
Co- requisite(s):
Credits: 2 L:0 T:0 P:4
Class schedule per week: 4
Class: M.Sc.
Semester / Level: II/04
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

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

Syllabus

List of Experiments

1.	Laboratory Design & Instrumentation in ACT.
2.	Quality Assurance in Animal tissue culture facility.
3.	Sterilization Techniques used in ACTL.
4.	Preparation of animal cell culture media.
5.	Isolation and Culturing Peripheral Blood Lymphocytes.
6.	Cell counting, Viability assay, Cryopreservation technique.
7.	Sub-culturing and maintenance of Cell line.
8.	In vitro anticancer assay (MTT Assay).
9.	DPPH radical scavenging assay.
10.	Genomic DNA Isolation from animal tissue.

Books Recommended:

TEXT BOOKS:

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

REFERENCE BOOKS:

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

Gaps in the syllabus (to meet Industry/Profession requirements):**Course Delivery Methods**

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT425

Course title: PLANT BIOTECHNOLOGY

Pre-requisite(s): Nil

Co- requisite(s): Nil

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/4

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

1.	Acquire knowledge about layout of plant tissue culture lab, culture environment, learn varied sterilization techniques.
2.	Learn the fundamentals of plant totipotency nature, culturing plant cells and tissues, designing of culture environment.
3.	Gain knowledge about protoplast isolation , purification and culture techniques.
4.	Acquire knowledge about molecular markers and their use in development of stress resistant crop plants.
5.	Get knowledge about plant transgenic development, varied methods of gene transfer, and get exposure about gene editing and methods involved.

Course Outcomes

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

1.	Demonstrate the knowledge about the techniques of Plant Tissue Culture techniques, 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 <i>in vitro</i> 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

Syllabus

Module-1: Practical aspects of plant tissue culture: Design and layout of laboratory, various components of culture media and types, sources of contaminants and various sterilization techniques, advantages and applications.

8L

Module-2: Micropropagation: Maintenance and growth of callus and suspension culture, Production of secondary metabolites, Various stages of micropropagation, Organogenesis, Embryogenesis, Artificial Seeds, Somaclonal variation, Production and use of haploids.

8L

Module-3: Protoplast Technology: Protoplast isolation and regeneration, Protoplast fusion and Somatic hybridization, Cytoplasmic hybridization, Uptake of foreign cellular components, Gene transfer with the use of protoplast, Identification, selection and characterization somatic hybrid cells.

8L

Module-4: Molecular Markers: Different molecular markers, DNA Microarray; Construction of Molecular Maps, Marker Assisted Selection, Use of Molecular Markers in the development of crops adaptable to stresses.

8L

Module-5: Transgenic Technology: Vectors and *Agrobacterium* mediated gene transfer, Direct gene transfer, Genetically modified value added crops and social issues, Molecular farming for biopharmaceuticals, Engineering of chloroplast genome, Gene editing with TALEN and CRISPER technology, Resistance against biotic and abiotic stresses.

8L

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 BOOKS:

1. A. Mizrahi, Biotechnology in agriculture, Wiley-Blackwell; Volume 9 edition (1988)
2. S. Natesh, Biotechnology in agriculture, South Asia Books (November 1, 1987)
3. Dixon and Gonzales, Plant cell culture – a practical approach. IRL Press; 2 edition (1995)
4. 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

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT426

Course title: PLANT BIOTECHNOLOGY LAB

Pre-requisite(s):

Co- requisite(s): BT425

Credits: L: 0 T: 0 P: 4

Class schedule per week: 04

Class: M.Sc

Semester / Level: II/4

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students to:

1.	Acquire knowledge about layout of plant tissue culture lab, culture environment, learn varied sterilization techniques.
2.	Learn the fundamentals of plant totipotency nature, culturing plant cells and tissues, designing of culture environment.
3.	Gain knowledge about protoplast isolation , purification and culture techniques.
4.	Acquire knowledge about molecular markers and their use in development of stress resistant crop plants.
5.	Get knowledge about plant transgenic development, varied methods of gene transfer, and get exposure about gene editing and methods involved.

Course outcomes:

1.	Demonstrate the knowledge about the techniques of Plant Tissue Culture techniques, 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
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.	Production of secondary metabolites under <i>in vitro</i> conditions .

Syllabus

List of Experiment

1. Demonstration of about various instruments/equipment used in the said lab.
2. Preparation of and sterilization of Culture Media.
3. Inoculation of explant in solid culture media.
4. Growth pattern analysis of inoculated explant.
5. Subculture of callus for the development of cell suspension culture.
6. Artificial seed preparation by encapsulation of somatic embryos.
7. Development of anther culture for the haploid production.
8. Agrobacterium mediated transformation for hairy root culture.
9. Protoplast isolation and its regeneration.

Books Recommended:

TEXT BOOKS

1. O.L. Gamborg and G. C. Phillips (Eds.): Plant Cell, Tissue and organ Culture: Fundamental methods. A Springer Lab Manual.
2. M. K. Razdan: An introduction to plant tissue culture. Science Publishers (2003) 2nd ed.
3. Timir Baran Jha and Biswajit Ghosh: Plant Tissue Culture: Basic and Applied

REFERENCE BOOKS:

5. Dixon and Gonzales, Plant cell culture – a practical approach.
6. 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

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT427

Course title: BIOMEDICAL EQUIPMENT & DEVICES

Pre-requisite(s): Nil

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

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

Syllabus

Module-I: Bioelectric Recorder: Factors in making measurement, Electrocardiography (ECG), Electromyography (EMG), electroencephalography (EEG), evoked potentials analysis. Electroretinography (ERG), Electro-Oculography (EOG).

(8L)

Module-II: 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.

(8L)

Module-III: Therapeutic Devices: Pacemakers, Defibrillators, Physiotherapeutic diathermies, nerve and muscle stimulator, electroshock therapy. Medical linear accelerator, Co60 Machine.

(8L)

Module-IV: Surgical Devices: Surgical diathermy, Heart lung machine, extra corporeal membrane oxygenator, intra-aortic balloon pump, surgical laparoscopy, lithotripsy, Sterilization equipment.

(8L)

Module-V: Analytical Instruments: Principle and applications of Blood Cell counter and Biochemical analysers.

(8L)

Books Recommended:

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. Webster, 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 Edition, PWS Publishers, Boston, 1986.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics
3. Industrial visits

POs met through Gaps in the Syllabus: PO1, PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

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

POs met through topics beyond syllabus/Advanced topics/Design: PO4

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD3
CO2	CD1, CD3, CD5
CO3	CD2, CD4
CO4	CD4
CO5	CD3, CD4, CD5, CD7

COURSE INFORMATION SHEET

Course code: BT428

Course title: BIOMEDICAL INSTRUMENTATION LAB

Pre-requisite(s):

Co- requisite(s): BT427

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

CO1	Understand the components of man-machine interaction.
CO2	Understand the fundamentals of the concept and design of biosignal recorder.
CO3	Identify the electrical hazards associated with biosignal recording so that the safety equipment can be devised or suggested.
CO4	Analysing a biosignal recorder.
CO5	Work in an interdisciplinary team.

Syllabus

List of Experiments

1. To Study of electrical and electronics components and instruments.
2. To study different types of electrodes and sensors used in bio-potential recordings.
3. To record and analyse different types of noises in biosignals.
4. To apply and analyse the effect of different digital filters in removing noises from electrocardiogram.
5. To apply and analyse the effect of different digital filters in removing noises from electromyogram.
6. To apply and analyse the effect of different digital filters in removing noises from electroencephalogram.
7. To distinguish different bands of electroencephalogram using application of different filters.
8. To analyse the characteristics of different types of electrolytic medium between electrode and body.
9. To separate out different heart sounds from phonocardiogram.
10. To perform an experiment in evaluating FFT of different recorded biosignals.
11. To perform an experiment in evaluating PSD of different recorded biosignals.
12. To correlate the different body activities with variable assigned task.

Books Recommended:

Text Books:

1. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown, Pearson; 4 edition (2000)
2. Handbook of Biomedical Instrumentation by R. S. Khandpur, McGraw Hill Education; Third edition (2014)
3. Biomedical Instrumentation and Measurement by L. Cromwell et al. Prentice Hall India Learning Private Limited; 2 edition

Reference Books:

1. Biomedical Digital Signal Processing by W. J. Tompkins. Prentice Hall; Har/Dskt edition (1993)
2. Biomedical Signal Processing: Principles and Techniques by D C Reddy. Tata McGraw-Hill Education, 2005.

Course Evaluation:

Written test, viva and performance examinations

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

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics

POs met through Gaps in the Syllabus: PO1, PO2, PO3

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: PO4

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD2
CO2	CD1, CD3
CO3	CD1, CD3, CD4
CO4	CD3, CD7
CO5	CD3, CD5, CD7

COURSE INFORMATION SHEET

Course code: BT429

Course title: CONCEPTS IN NANOBIO TECHNOLOGY

Pre-requisite(s):

Co- requisite(s):

Credits: 3 L:03 T: P:

Class schedule per week: 03

Class: M.Sc

Semester / Level: II/04

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand the concept & phenomena of nanotechnology in biological and biomedical research
2.	To guide the students to comprehend how nanomaterials can be used for a diversity of analytical and medicinal rationales.

Course Outcomes

After the completion of this course, students will be:

CO 1	Understand the fundamentals of nanoscience, nanotechnology and biology with in detail knowledge of different nanomaterial types and properties
CO 2	Acquire the knowledge on different nanofabrication methods. Skilled in various characterization techniques.
CO 3	Recognize and relate to the structural and functional principles of biomolecular interactions to nanomaterials, factors involved and their significance in designing nanomaterials and nanodevices.
CO 4	Familiarize themselves with nanobiotechnology potentialities and concerns associated with nanomaterials usage and handling. Able to apprehend and explain use of nanomaterials in different medical/environmental applications. Analyse the possible impact of this technology on society, industry and environment

Syllabus

Module 1: Introduction to Nanoworld: The world of small dimensions: Introduction and scientific revolutions, Dimensionality and size dependent phenomena, Properties at nanoscale, Nanomaterials synthesis techniques (Top-Down, Bottom-Up, Biological).

8L

Module 2: Introduction to Nanostructures: Classification & Types: Classification based on dimensionality, (synthesis, properties and applications of Fullerenes, Carbon nanotube, Metal nanoparticles, Quantum dots, Dendrimers, Biological nanomaterials

8L

Module 3: Nanoscale visualization & Characterization techniques: Electron microscopy: FESEM, HRTEM, Scanning probe microscopy: AFM, STM, Diffraction techniques (XRD), UV-Vis & FTIR, light scattering

8L

Module 4: Bionanotechnology: Biomolecular Structure and Stability, Protein Folding, Self-assembly, self-organization, molecular recognition, Flexibility, Information-Driven Nanoassembly, Energetics, Chemical Transformation, Biomolecular Motors, Traffic Across Membranes, Machine-Phase Bionanotechnology

8L

Module 5: Biomedical applications of nanomaterials & Challenges: Drug delivery, Tissue engineering, cancer nanotechnology, nano labels, Biosensors, Nanobiosensors nanomedicine, bioimaging, Nanotoxicology challenges, Impact of nanotechnology on society and industry

8L

Books Recommended:

TEXT BOOKS:

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

REFERENCE BOOKS:

1. T. Pradeep, "A Textbook of Nanoscience and Nanotechnology", Tata McGraw Hill Education Pvt. Ltd., 2012
2. 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

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

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Individual assignment, Theory (Quiz and End semester) examinations

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD5
CO2	CD1,CD3, CD4, CD5
CO3	CD1, CD2, CD5
CO4	CD1,CD3, CD4, CD5, CD6, CD8

COURSE INFORMATION SHEET

Course code: BT430

Course title: BASIC NANOBIO TECHNOLOGY LAB

Pre-requisite(s):

Co- requisite(s): BT 429

Credits: 2 L: T: P:04

Class schedule per week: 04

Class: M.Sc

Semester / Level: II/4

Branch: Biotechnology

Name of Teacher:

Course Objectives

This course enables the students:

1.	To understand the concept & phenomena of nanotechnology in biological and biomedical research
2.	To guide the students to comprehend how nanomaterials can be used for a diversity of analytical and medicinal rationales.

Course Outcomes

After the completion of this course, students will be:

CO 1	Acquire the knowledge on different nanofabrication methods. Skilled in various characterization techniques.
CO 2	Employ nanomaterials for analysis and sensing technique
CO 3	Recognize and relate to the structural and functional principles of biomolecular interactions to nanomaterials, factors involved and their significance in designing nanomaterials.
CO 4	Familiarize themselves with nanobiotechnology potentialities and concerns associated with nanomaterials usage and handling.

Syllabus

List of Experiments

1. To study various instruments used for nanoscale characterization
2. Synthesis and characterization of nanomaterial by physical method
3. Synthesis and characterization of nanomaterial by wet chemical method
4. Biological synthesis and characterization of nanoparticles
5. Synthesis and characterization of polymeric carrier for nanoparticle delivery
6. Bioconjugation & characterization of biomolecules/drug with nanomaterial
7. Study of dispersity and stability profile of nanoparticles

Books Recommended:

TEXT BOOKS:

1. Gerrard Eddy Jai Poinern, Nanobiotechnology Laboratory course material, CRC Press (2014)

REFERENCE BOOKS:

1. Challa, "Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact", Wiley – VCH, 2005
2. Andrew Collins, "Nanotechnology Cookbook: Practical, Reliable and Jargon-free Experimental Procedures", Elsevier, 2012

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

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

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Individual assignment, Theory (Quiz and End semester) examinations

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

Course Outcomes	Course Delivery Method
CO1	CD1, CD5
CO2	CD1, CD5
CO3	CD1, CD5
CO4	CD1, CD5

COURSE INFORMATION SHEET

Course code: BT501

Course title: IMMUNOTECHNOLOGY

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: III/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To recapitulate the previous knowledge of immunology and to establish thorough understanding of various structure & function at cellular and molecular level.
2.	To provide a thorough understanding of the various immunology concepts in study of cell biology and to study the different tools and techniques used to study the immunology at molecular level.
3.	To provide students with a deep insight about the immunological reactions with emphasis on the effector mechanisms, rationale behind the immunological interactions leading to successful reactions.
4.	To teach our students to have a concrete knowledge about immunology human system to study about the basis of the interaction as well as the genes involved in it.
5.	To acquire in-depth knowledge of the molecular events involved in immunological processes and their regulation. To provide wider and global perspective of techniques involved as well as the genetic basis of the immunological diseases and their cure, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.

Course Outcomes:

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

CO1	to apply knowledge of immunology in various cellular functions, inculcate a knowledge of various issues related to immunological reactions eg the application of and research involved in functioning of the different molecules and moieties in the reactions.
CO2	to design and analyze the experiments related with the different molecules involved in immunology and use of the various techniques in the immunology to study the kinetics and rationale behind each phenomenon.
CO3	to identify, formulate, and solve problems arisen due to the inefficient functioning of the various immunological phenomenon leading to various immunological diseases.
CO4	to use the techniques, skills, and modern tools necessary for imbalances in various life processes, design a molecular cell biology research project, collect and analyze data, and interpret results

Syllabus

Module 1: Introduction: brief history of Immunotechnology, immune system, components of immune system, Innate and adaptive immune system, external and internal barriers, phagocytosis. Antigen clearance mechanism.

(8L)

Module 2: The antigens and antibodies, immunogenicity, MHC, cell-mediated and humoral immunity, effector mechanism. Kinetics of Antigen antibody interaction, thermodynamics, different mathematical, Models of antigen antibody interaction with single and multiple binding sites.

(8L)

Module 3: Techniques in Immunotechnology, Blood groups: AB, Rh system, Precipitin curve, Immuno diffusion, Immuno electrophoresis, Agglutination, Widal test, Radioimmunoassay: ELISA, Immuno fluorescence, comet assay, FACS. ELISPOT assay, immunofluorescence, Surface plasmon resonance, Biosensor assays for assessing ligand – receptor interaction, Staining techniques for live cell imaging and fixed cells; Flow cytometry, Instrumentation, Applications; Cell Functional Assays – lymphoproliferation, Cell Cytotoxicity, mixed lymphocyte reaction, Apoptosis, Cytokine expression; Cell cloning, Reporter Assays, In-situ gene expression techniques; Cell imaging Techniques- In vitro and In vivo; Immuno-electron microscopy; In vivo cell tracking techniques; Microarrays; Transgenic mice, gene knock outs

(8L)

Module 4: Immunodeficiency, animal models of immunodeficiency, Diagnosis, therapeutic approaches. Antibody engineering, antigen engineering, Rationale of vaccine design, types of vaccines (live, killed, attenuated, Sub unit vaccines; Recombinant DNA and protein based vaccines, plant-based vaccines and reverse vaccinology; Peptide vaccines, conjugate vaccines), Passive Immunization; Antibody, Transfusion of immuno-competent cells, Stem cell therapy; Cell based vaccines vaccine production, Catalytic antibodies, antibody immunotherapy, productions of drugs to allergies. Hybridoma technology.

(8L)

Module 5: Reactor system for Production of Polyclonal antibodies , antigen preparation and modification, adjuvants, dose and route of antigen administration, collection of sera, purification of antibodies Production of cellular chemicals like Interferons, Interleukin etc.

(8L)

Books recommended:

TEXT BOOK

1. Kuby J, Immunology, WH Freeman & Co., 2000.
2. Tizard, Immunology, fourth edition, Thomson Asia pvt. Ltd, 2004.
3. Talwar G.P., and Gupta S.K., “A hand book of practical and clinical immunology”, Vol. 1 & 2, CBS Publications, 1992.

REFERENCE BOOK

1. Textbook of Basic and Clinical Immunology” by Sudha Gangal
2. Immunology” by Roitt I and Male Brostoff

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Design of real-time research projects.

POs met through Gaps in the Syllabus: PO2, PO3, PO5

Topics beyond syllabus/Advanced topics/Design:

Design optimization for molecular cell biology projects.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO2, PO3, PO4, PO5.

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT502

Course title: ENVIRONMENTAL BIOTECHNOLOGY

Pre-requisite(s):

Co- requisite(s):

Credits: 2 L:0 T:0 P4

Class schedule per week: 04

Class: M. Sc.

Semester / Level: III/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

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

Syllabus

Module I: Introduction: Ecosystem, Concept of biosphere, Biodiversity and its conservation strategies, Natural resources, Environmental Protection Acts and Legislations, National and international status, Environmental Planning for sustainable development 8L

Module II: Environmental pollutants and waste water: Sources of pollutants for Air, Water, Noise, Land; Pollution control and management- Environmental monitoring & sampling, Physical, chemical and biological methods and analysis of different pollutants, Microbial treatment of waste water (sewage or industrial effluent)- aerobic and anaerobic methods 8L

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

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

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

Books recommended:

TEXT BOOK

1. Dash and Dash, Fundamentals of ecology, 3rd Ed., TMH Education, 2009 (T1)
2. Mohapatra, Text Book of Environmental Biotechnology, 1st Ed., I K International Publishing House Pvt. Ltd, 2007 (T2)

REFERENCE BOOK

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

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

Course Delivery Methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT503
Course title: BIOSAFETY, BIOETHICS & IPR
Pre-requisite(s):
Co- requisite(s):
Credits: L:3 T:0 P:0
Class schedule per week: 03
Class: M.Sc.
Semester / Level: III/05
Branch: Biotechnology
Name of Teacher:

Course Objectives:

This course enables the students to:

1.	To create awareness on IPR issues and need for knowledge in patents in biotechnology
2.	To understand the biosafety regulations and ethical practices in biotechnology
3.	To become familiarize with the ethical practices in biotechnology

Course Outcomes:

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

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

Syllabus

Module-1: Intellectual Property: Patents, Trademarks, Copyright, Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs, IPs of relevance to Biotechnology and Case Studies; Agreements and Treaties, Indian Patent Act 1970 & recent amendments.

8L

Module-2: Patents and Concept of Prior Art: Types of patent applications, Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees, Invention in context of “prior art”.

8L

Module-3: Patent Filing Procedures: National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting—disclosure/non-disclosure; Patent licensing and agreement Patent infringement.

8L

Module-4: Biosafety: Introduction to Biological Safety Cabinets; Biosafety Levels of Specific Microorganisms; Biosafety guidelines: Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, applications in food and agriculture; Environmental release of GMOs; Risk Analysis, Risk management and communication; National Regulations and relevant International Agreements, Cartagena Protocol.

8L

Module-5: Bioethics: Ethical implications of biotechnological products and techniques, Social and ethical implications of biological weapons.

8L

Books Recommended:

Text books:

- 1: Deepa Goel & Shomini Parashar IPR, Biosafety and Bioethics, Pearson Education India, (2013)
- 2: Anupam Singh Intellectual Property Rights and Bio-Technology Biosafety and Bioethics, Narendra Publishing House, (2012)

Reference books:

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

Course Delivery Methods

CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training

CD6	Self- learning such as use of NPTEL materials and internets
CD7	Simulation

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT504

Course title: MOLECULAR GENETICS & PHARMACOGENOMICS

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: III/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Learn the aspects of molecular genetics pharmacogenetics & pharmacogenomics;
2.	Gain comprehensive knowledge about pharmacogenetic and pharmacogenomic aspects of multi drug resistance associated protein, organic anion transporter peptide family media constituents. They will also learn about pharmacogenomics of asthma, chemo therapeutic agents in cancer, alcoholism and neurodegenerative diseases;
3.	Identify, locate, analyse frequencies and SNPs;
4.	Process comparative genomic data, proteome and related genetic information.

Course Outcomes:

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

CO1	Discuss various aspects of molecular genetics pharmacogenetics & pharmacogenomics;
CO2	Interpret comprehensive knowledge about pharmacogenetic and pharmacogenomic aspects of multi drug resistance associated protein, organic anion transporter peptide family media constituents, asthma, chemo therapeutic agents in cancer, alcoholism and neurodegenerative diseases;
CO3	Distinguish SNPs as genetic marker;
CO4	Analyse comparative genomic data, proteome and genetic information.

Syllabus

Module-1: Organisation of eukaryotic and prokaryotic genome, Methods of gene analysis, Comparative genome analysis, Analysis of proteome, concepts of genetics, pharmacogenetics and pharmacogenomics. (8L)

Module-2: SNPs as genetic marker: Identification, location, frequency and analysis of SNPs; SNPs based pharmacogenomic markers. (8L)

Module-3: Pharmacogenomics and Drug design: In silico design of small molecules, Automated drug design methods, Structure based drug design methods, Ligand based drug design methods. (8L)

Module-4: Pharmacogenomics of human P- glycol protein and drug transporters (Multi drug resistance associated Protein, Organic anion transporter peptide family). (8L)

Module-5: Pharmacogenomics aspects in Asthma, Chemo therapeutic agents in cancer, Alcoholism, Neurodegenerative diseases. (8L)

Books recommended:

TEXT BOOK

1. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Oliver Kayser, Rainer H. Miller, Wiley Interscience, 2004
2. Pharmaceutical Biotechnology by S.P. Vyas, V.K.Dixit, 1st ed,CBS Publishers & Distributors, New Delhi, 1998
3. Pharmaceutical Biotechnology by Daan J.A. Crommilin & Robert D. Sindelar (eds.) Routledge, Taylor & Francis group, London 2002

REFERENCE BOOK

1. Pharmacogenomics: The search of Individual Therapies, Julio Licinio and Ma-li Wong, Wiley-Blackwell; 2002

Course Evaluation:

Individual assignment, Presentation, 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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT505

Course title: IMMUNOTECHNOLOGY LAB

Pre-requisite(s): Basics of immunology

Co- requisite(s): None

Credits: 2 L: T:0 P:4

Class schedule per week: 4

Class: M.Sc.

Semester / Level: IV/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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:

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

CO1	Apply knowledge of immunology, inculcate a knowledge of various issues related to immunology eg vaccines etc. and immunological techniques.
CO2	Design and conduct experiments, as well as to analyze and interpret data of different immunological methods. To identify, formulate, and solve problems arisen due to the inefficient functioning of the immune system.
CO3	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.
CO4	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.

Syllabus

List of Experiments

1. To detect the blood group of the given sample.
2. To perform differential count (DLC) of given sample.
3. To perform the Technique of Radial immunodiffusion
4. To learn and perform the technique of Ouchterlony Double Diffusion Technique
5. To perform the pregnancy test with the help of Pregnancy Kit
6. To learn the technique of Immunoelectrophoresis
7. To study the technique of Rocket Immunoelectrophoresis for determination of concentration of antigen in unknown sample
8. To perform widal test for detection of typhoid.
9. To study the different immunoinformatics tools.
10. To perform the sandwich Dot ELISA Test for antigen detection
11. To perform Affinity chromatography for antibody purification.
12. To identify cells in a blood smear
13. To isolate monocytes from blood
14. To Isolate peripheral blood mononuclear cells
15. Identification of t cells by T-cell rosetting using sheep RBC

Books recommended:

1. Immunology: Theoretical and practical concepts in Laboratory Medicine. Hannah D. Zane, Saunders; 1 edition (2001)
2. Clinical Immunology and Serology: A Laboratory Perspective By Christine Dorresteyn Stevens, F.A. Davis Company; 2nd Revised edition edition (2009)

Course Evaluation:

Lab (Quiz and End semester) examinations

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

Design of real-time research projects.

POs met through Gaps in the Syllabus: PO2, PO3, and PO5

Topics beyond syllabus/Advanced topics/Design:

Design optimization for molecular cell biology projects.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO2, PO3, PO4, and PO5.

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY
METHOD

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

COURSE INFORMATION SHEET

Course code: BT506

Course title: ENVIRONMENTAL BIOTECHNOLOGY LAB

Pre-requisite(s):

Co- requisite(s):

Credits: 2 L:0 T:0 P:4

Class schedule per week: 04

Class: M. Sc.

Semester / Level: II/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Identify and explain the environmental factors responsible for the pollution
2.	Select the appropriate method for the treatment of wastewater and solid waste management
3.	Select and apply Suitable bioremediation methods for the treatment
4.	Expose to significance of biofuels and organic farming

Course Outcomes:

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

CO1	Apply knowledge on wastewater management
CO2	Design techniques for bioremediation of xenobiotics
CO3	Identify and evaluate the importance of biofuels and organic farming
CO4	Apply the scientific method by stating a question; researching the topic; determining appropriate tests; performing tests; collecting, analyzing, and presenting data and effective communicate with both specialist and non-specialist audiences/community

Syllabus

List of Experiments

1. Estimation of biological oxygen demand in sewage samples
2. Estimation of chemical oxygen demand in sewage samples
3. Determination of total dissolved solids in water samples
4. Determination of coliforms to estimate quality of water samples
5. Isolation of xenobiotic degrading bacteria by selective enrichment technique
6. Estimation of heavy metals in water/soil by atomic absorption spectrophotometry
7. Production of microbial fertilizers
8. Preparation of formulations of microbial biopesticide

Books Recommended:

TEXT BOOK

1. James G. Cappuccino and Natalie Sherman: Microbiology: A Laboratory Manual, 7th Edition, Dorling Kindersley (India) Pvt. Ltd., 2005

REFERENCE BOOK

2. Metcalf and Reddy Inc et al, Wastewater Engineering: Treatment and Reuse, 4th Ed., McGrawHill Higher Education, 2002

Course Evaluation:

Progressive Evaluation (Viva Voce), Practical (End semester) examination

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

POs met through Gaps in the Syllabus:

Topics beyond syllabus/Advanced topics/Design

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

Course Delivery Methods

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

Mapping between Objectives and Outcomes

Mapping of Course Outcomes onto Program Outcomes

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT508

Course title: METABOLOMICS

Pre-requisite(s):

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: III/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	State and comprehend the fundamental concepts of metabolism and metabolic regulation network at different label
2.	Extend comprehensive knowledge about analysis of metabolic control and metabolic networks
3.	Demonstrate concept about Metabolic flux analysis and its applications with the help of specific algorithms
4.	Gain knowledge about the techniques for Metabolic Control Analysis with different programming and its application in biological systems

Course Outcomes:

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

CO1	Elucidate the theoretical knowledge of metabolism and metabolic regulation network
CO2	Analyze and design the metabolic control and metabolic networks with programming/algorithms
CO3	Collect the proficient knowledge to solve metabolic flux balance analysis
CO4	Develop the key skills of metabolic control analysis in different systems

Syllabus

Module I: Metabolism Basics: Overview of cellular metabolism, Different models for cellular reactions, Metabolic regulation network at enzyme level and whole cell level, Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation. (8L)

Module II: Metabolic Flux Analysis: Linear programming, Cell capability analysis, Genome scale, isotope labeling, Integration of anabolism and catabolism, Experimental determination method of flux distribution, Metabolic flux analysis and its applications, Thermodynamics of cellular processes. (8L)

Module III: Metabolic Networks: Stoichiometry, kinetics, mass balances for the steady state, mass balances for the transient case, Metabolic pathway modeling, Analysis of metabolic control and the structure, metabolic networks, Metabolic pathway synthesis algorithms. (8L)

Module IV: Metabolic Control Analysis: Nonlinear programming, Synthesis and design of metabolic networks, Integer programming, Mixed-integer nonlinear programming, Case studies about ethanol production, amino acid biosynthesis, metabolism in bacteria and yeast. (8L)

Module V: Metabolomics Applications: Application in pharmaceuticals, Chemical bioprocess, Food technology, Agriculture, Environmental bioremediation, Biomass conversion, Secondary metabolites production. (8L)

Books recommended:

TEXT BOOK

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

REFERENCE BOOK

1. Biochemistry by J. M. Berg, J. L. Tymoczko and Lubert Stryer (2002) Fifth Edition, W.H. Freeman, New York.
2. Understanding the Control of Metabolism by David Fell (1997) Portland Press, London
3. Metabolism at a Glance by J. G Salway (1994) Blackwell Scientific Publications, Oxford
4. Systems Biology: Properties of Reconstructed Networks. B. O. Palsson, Cambridge University Press, 2006.
5. Modeling Metabolism with Mathematica. P. J. Mulquiney and P. W. Kuchel, CRC Press, 2003.
6. Pathway Analysis and Optimization in Metabolic Engineering. N. V. Torres and E. O. Voit, Cambridge University Press, 2002.
7. The Regulation of Cellular Systems. R. Heinrich and S. Schuster, Chapman & Hall, 1996.
8. Metabolic network reconstruction: Nature Reviews Genetics (2006) 7:130-141.

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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT 509

Course title: DOWNSTREAM PROCESSING

Pre-requisite(s): BT 416

Co- requisite(s): None

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

Class schedule per week: 03

Class: M. Sc

Semester / Level: III/04

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

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

Course Outcomes:

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

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

Syllabus

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

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

Module III: Chromatographic techniques: Principles and practice of liquid chromatography, gradient elution chromatography, ion-exchange chromatography, size exclusion chromatography, reversed phase chromatography, hydrophobic interaction chromatography, affinity chromatography; HPLC and its applications. (8L)

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

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

Books recommended:

TEXT BOOKS:

1. Nooralabettu Krishna Prasad, Downstream Process Technology, 1st Ed., Phi learning Pvt. Ltd, New Delhi, 2010
2. B. Sivasankar, Bioseparations: Principles and Techniques, 1st Ed., Prentice Hall, 2005
3. Michael L. Shuler, Fikret Kargi, Bioprocess Engineering – Basic Concepts, 2nd Ed., Pearson Education India, 2015

REFERENCE BOOKS:

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

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

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 Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT510

Course title: BIOTECHNOLOGY ENTREPRENEURSHIP

Pre-requisite(s): Nil

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: III/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Develop awareness about the biotechnology enterprise.
2.	Exposure of management principles and the global scenario of biotechnology industries.
3.	Develop skills to work in interdisciplinary team.

Course Outcomes:

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

CO1	Prepare project report for biotechnology entrepreneurship.
CO2	Address the market challenges for a new enterprise.
CO3	Setup enterprise for new biotechnology product.
CO4	Assess the global market scenario of their product.

Syllabus

Module-I: Introduction: Concept of entrepreneurship, Fundamentals of Marketing.

8L

Module-II: Entrepreneurship Traits & Motivation: Growth of entrepreneurship, The marketing and selling of Biotechnology, Establishment and marketing of biotechnology company, Effective advertising.

8L

Module-III: Entrepreneurial Development: Training, Institution in aid of entrepreneur, Power and importance of Positioning of a company name and product.

8L

Module-IV: Start-up: Setting of a small industry, location of an enterprise, steps of starting small industry, Incentive & subsidies for industry, Problems of entrepreneurship, The Art of Negotiation, Workable marketing and the strength of distribution. Opportunities and lessons in international marketing.

8L

Module-V: Problem and Solution of Entrepreneurship: Risk and benefit, Steps involved in commercialization of a biotechnological product, Case studies.

8L

Books Recommended:

TEXT BOOKS:

1. Dynamics of Entrepreneurial development & management; Vasant Desai, Himalay. Publications.
2. Entrepreneurship reflection & investigation; M.S. Bisht & R.C. Mishra, Chugh Publication.
3. Entrepreneurship development in India; Samiuddin, Mittal Publication.

REFERENCE BOOKS:

1. Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market.
2. Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harvard Business School Press: 2006.
3. Design and Marketing of New Products by Urban and Hauser, ISBN 0-13-201567-6.
4. Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences, The National Academy Press.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

1. Conducting presentations in group and writing reports
2. Giving assignments to the students on some relevant topics
3. Industrial visits

POs met through Gaps in the Syllabus: PO4, PO5

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on entrepreneurship development
2. Lecture on processes to develop new biotechnology product(s)

POs met through topics beyond syllabus/Advanced topics/Design: PO4

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT511

Course title: IMAGING CONCEPT AND DEVICES

Pre-requisite(s): BT413, BT427

Co- requisite(s): None

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

Class schedule per week: 03

Class: M.Sc

Semester / Level: III/05

Branch: Biotechnology

Name of Teacher:

Course Objectives:

This course enables the students to:

1.	Impart knowledge for interdisciplinary science and technology.
2.	Understand the physics of medical imaging systems.
3.	Learn the technicality associated with imaging instrumentation.
4.	Understand the aspects of applications of different imaging modalities.

Course Outcomes:

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

CO1	Understand the general physics in imaging systems.
CO2	Learn and understand the instrumentation of different image acquisition systems.
CO3	Process and analyse the anatomical and physiological images.
CO4	Analyse the radiation hazards and its prevention.

Syllabus

Module-I: 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. 8L

Module-II: 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. 8L

Module-III: 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. 8L

Module-IV: Radio Nuclide Imaging: Interaction of nuclear particles and matter, Nuclear sources, Radionuclide generators, Nuclear radiation detectors, Rectilinear scanner, scintillation camera, SPECT, PET. 8L

Module-V: 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. 8L

BOOKS RECOMMENDED

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.

REFERENCE BOOK

1. Medical Imaging Signals and Systems by Jerry L Prince & Jonathan M Links, Pearson Prentice Hall.

Course Evaluation:

Individual assignment, Theory (Quiz and End semester) examinations

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

1. Conducting presentations in group and writing reports.
2. Giving assignments to the students on some relevant topics.

POs met through Gaps in the Syllabus: PO2, PO3

Topics beyond syllabus/Advanced topics/Design:

1. Lecture on advance imaging modalities.

POs met through topics beyond syllabus/Advanced topics/Design: PO1, PO4

Course Delivery Methods

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

MAPPING BETWEEN COURSE OUTCOMES AND PROGRAM OUTCOMES

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

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

MAPPING BETWEEN COURSE OUTCOMES AND COURSE DELIVERY METHOD

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

COURSE INFORMATION SHEET

Course code: BT413

Course title:

Biosignal Acquisition System

Pre-requisite(s):

Basic Electrical and Electronics measurement

Co- requisite(s):

Fundamental knowledge of human physiological system

Credits:

L: 3 T: 0 P: 0

Class schedule per week:

03

Class:

M.Sc.

Semester / Level:

I

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 System

Module-1: *Man-machine instrumentation system*: Category and factors in measurement, biometrics, problems encountered in measuring a living system, Electrical safety considerations.

(8)

Module-2: *Signals and noise*: Types of bio-signal and its sources, Electrodes for bio-physiological sensing, Transducers and other sensors, 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: *Biotelemetry*: Electrophysiological telemetry, Radio telemetry system, Portable telemetry system, Land-line telemetry system.

(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
End Sem Examination Marks	60
Assignment / Quiz (s)	15

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			M								
ii		H	H	H	M	M						
iii	H				H	M		H	M		M	
iv				H	H				M	M		M
v									H	M	H	

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

Department of Bio-Engineering
Birla Institute of Technology, Mesra, Ranchi

M.Sc. Biotechnology
(No of Seats-30)

Course Structure

Semester-I					
Course Code	Course Title	Credits			
		L	T	P	Total
SBT 1001	Cell Biology & Molecular Genetics	3			3
SBT 1003	Biochemistry	3			3
SBT 1005	Microbiology	3			3
SBT 1007	Mathematics for Biologists	3	1		4
SBT 1002	Cell Biology & Biochemistry Lab			2	2
SBT 1006	Microbiology Lab			2	2
	Breadth Paper 1	3			3
Total Credits					20

Semester-II					
Course Code	Course Title	Credits			
		L	T	P	Total
SBT 2001	Enzyme Technology	3			3
SBT 2003	Molecular Biology & rDNA Technology	3			3
SBT 2005	Bioprocess Technology	3			3
SBT 2007	Bioinformatics	3	1		4
SBT 2002	Enzyme & Bioprocess Technology lab			2	2
SBT 2004	Molecular Biology & rDNA Technology lab			2	2
	Breadth Paper 2	3			3
Total Credits					20

Semester-III					
Course Code	Course Title	Credits			
		L	T	P	Total
SBT 3001	Immunotechnology	3	1		4
SBT 3003	Environmental Biotechnology	3			3
SBT 3005	Biosafety, Bioethics & IPR	3			3
	Elective I (Any one of the following)	3			3
SBT 3007	Plant Biotechnology				
SBT 3009	Animal biotechnology				
SBT 3011	Industrial Biotechnology				
SBT 3013	Pharmaceutical Biotechnology				
SBT 3015	Computational Biology				
	Elective II (Any one of the following)	3			3
SBT 3017	Genomics and Proteomics				
SBT 3019	Bio Analytical Techniques				
SBT 3021	Down Stream processing				
SBT 3002	Immunotechnology lab			2	2
SBT 3004	Environmental Biotechnology lab			2	2
Total Credits					20

Semester- IV		
Course Code	Course Title	Credits
SBT 4001	Project & Comprehensive Viva	20

Semester-I

SBT 1001 Cell Biology & Molecular Genetics

Module 1: Cell Basics:

Structure of Prokaryotic and Eukaryotic cells, membranes and cellular compartments, Structure and function of cell organelles – plasma membrane, cell wall, their structural organization; mitochondria, chloroplast, nucleus, and other organelles and their organization.

Module 2: Cell Motility:

Self assembly and structure of cytoskeleton filaments, how cells regulate cytoskeleton filaments, molecular motors, cilia, and flagella of prokaryotes and eukaryotes

Module 3: Cell-cell interactions:

General principles of cell communication, signal transduction pathways, signaling through G-protein linked cell surface receptors, signaling through enzyme linked cell surface receptors, signaling pathways that depend on regulated proteolysis.

Module 4: Cell cycle and its regulation:

Overview of the cell cycle control system, components of the cell cycle, cell cycle progression, intracellular control of the cell cycle events, extracellular control of cell division, cell growth, and apoptosis.

Module 5: Molecular biology Basics:

DNA structure, DNA replication in prokaryotes and eukaryotes, mechanics of DNA replication, enzymes, and accessory proteins involved in DNA replication.

Module 6: Central dogma of molecular biology:

RNA transcription, transcription factors, regulatory elements, transcription regulations. Translation machinery, mechanisms of initiation, elongation, and termination, regulation of translation, co- and post translation modifications of proteins

Module 7: Principles of genetics:

Inheritance, linkage and crossing over. Genes-definition, structure of eukaryotic and prokaryotic genes. The genetic code, gene expression and regulation in prokaryotes and eukaryotes. Mutations and mutagenesis-UV and chemical mutagens, types of mutations, mapping mutations at molecular level.

Textbook:

1. Molecular biology of the gene by Watson et. Al (5th edition) ISBN: 8177581813
2. Molecular biology of the cell by Bruce Albert et al (4th edition) ISBN: 815332181

Reference:

1. *Genes VII* by Benjamin Lewin, Oxford University Press ISBN: 019879276X
2. *Molecular Cell Biology*, by HarveyXodish, Matthew P. Scott, P Matsudaira, J Darnell, L Zipursky, Chris A. Kaiser, A Berk, M Krieger, publisher: W. H. Freeman; 5th edition, ISBN: 0716743663

SBT 1003 Biochemistry**Module 1: pH and Buffers:**

Concept of pH, pK, chemical equilibrium, structure of water, ionization of weak acids ionization of weak bases, Henderson-Hasselbalch equation, Biological buffer systems.

Module 2: Biomolecules:

Structure and classification of monosaccharides, oligosaccharides and polysaccharides, biological importance, structure, classification and properties of amino acids, peptide bonds, proteins, their physico-chemical properties, Nucleic acid (structure properties and importance.)

Module 3: Enzymes:

Nomenclature and classification, Units of activity, Coenzymes, active sites, effect of temperature and pH on activity, Inhibitors and Activators, Michaelis - Menten kinetics and significance. Isoenzymes

Module 4:

Allosteric enzymes, mechanism or regulation, sequential and concerted model, feedback inhibition, Isoenzymes

Module 5: Bioenergetics:

Laws of thermodynamics, Entropy and the role of free energy,role of ionic balance and membrane potential. Reversible and Irreversible processes.

Module 6: Carbohydrate metabolism:

Introduction, Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis, Pentose phostphate pathway,

Module 7:

TCA cycle, Electron transport chain and Oxidative phosphorylation

Textbook:

1. David L. Nelson, Albert L. Lehninger, Michael M. Cox, *Lehninger Principles of Biochemistry*, 4th Edition.W H Freeman & Co (April 2004)
2. Cohn and Stumpf, *Outlines of Biochemistry*, 4th Edition, John Wiley & sons

Reference:

1. Lubert Stryer, Jeremy Mark Berg, John L. Tymoczko, *Biochemistry*, 5th Edition
2. (Illustrated) by W H Freeman & Co
3. R Murray, D Granner et al. *Harper's Biochemistry* by 25th edition, Me Graw hill.
4. D Voet, *Biochemistry* by 2nd Edition, John Wiley & sons.

SBT 1005 Microbiology

Module 1:

Introduction to Microbiology: History and scope of microbiology, Types of microorganisms, prokaryotic and eukaryotic cell structure and function. Fine structure of Bacteria. Cell Cycle. Difference between gram positive and gram negative bacteria, Synthesis of peptidoglycan in Bacteria. Microbial Taxonomy

Module 2:

Techniques in microbiology: Pure culture Methods, Micrometry, Staining in Microbiology, Microscopy, sterilization, filtration, centrifugation. Air Sampling, Waste water analysis.

Module 3:

Microbial nutrition and growth: Nutritional and Growth Factors requirement of microorganisms, Nutritional Types of Microorganisms, Uptake of Nutrition, Culture Media and its types, Microbial Growth, Influence of Environmental Factors of Growth, Measurement of Microbial Growth, Batch Culture, Continuous Culture, Synchronous Growth, Fed-batch Culture. Control of microbial growth by physical and chemical agents

Module 4:

Microbial Metabolism: Role of ATP in metabolism, Oxidative-Reductive Reactions and electron carriers, Metabolic channelling, Catabolism of glucose and other carbohydrate, Anaerobic Respiration, Fermentations, Lipid Catabolism, Protein Catabolism, Oxidation of Inorganic Molecules. Photosynthetic fixation of CO₂, Synthesis of sugar, lipid and amino acids, Assimilation of inorganic Molecules by microorganisms.

Module 5:

Microbial Genetics: Nucleic acid Structure, Organization of DNA in microbial Cell, DNA Replication and its mechanisms, Pattern of DNA Synthesis, Structure of gene, Transcription, Translation, Plasmids, Types of Plasmids, Transposons and Its Types.

Module 6:

Diversity of microbial world: Soil Bacteria, aquatic bacteria, Rhizospheric bacteria, Photosynthetic Bacteria, Bacteria of extreme environment, Rickettsiae, Chlamydae, Mycobacteria, Mycoplasma. less bacteria, Actinomycetes, The Archaea.

Module 7:

Viruses: Viruses structure and characteristics, types of viral capsids and nucleic acids, Viral Taxonomy, Bacteriophage, Lytic and Lysogenic cycle of Viruses, Eucaryotic viruses .

Books Recommended:

- 1 Prescott, Harley, and Klein, Microbiology
- 2 Pelczar, Chan and Krieg, Microbiology
- 3 Stanier et al. General Microbiology
- 4 Tortora, Microbiology: an Introduction

SBT 1007 Mathematics for Biologists

Module 1:

Population models for a single species (discrete and continuous time models), Malthusian Models of resource limitations, Constant and random environment, simple spatial models, Discrete time population models, Logistic Map

Module 2:

Demography. Simple Age- and Size-Structured Populations, The Euler-Lotka demographic equation, Applications to the Theory of Life-History strategies.

Module 3:

Microbiological models: biodegradation and Chemostat Theory.

Module 4 & 5:

Enzyme Kinetics, Multi-species Communities: Competition Models, Coexistence, Predator-Prey Models, Optimal Foraging, Host-Parasite Models and their Dynamics, Models of Disease Transmission (epidemics).

Module 6:

Many Species Interactions, General Lotka-Volterra models, Applications of Lyapunov functions.

Module 7:

Spatially-Distributed models: Conservation equation, Random walk and diffusion, Fick's Laws, Diffusion in Biological Settings.

Textbooks:

1. Elements of Mathematical Biology by Mark Kot (CUP,2001).
2. Evolutionary Games and population dynamics by Joseph Hofbauer and Karl Sigmund (CUP,2002).
3. Mathematical Biology-I & II, J.D. Murray (Springer-Verlag Texts, 1989.)
4. A Primer in Ecology by N.J. Gotelli (Sinaur Associates Inc.).

SBT 1002 Cell Biology & Biochemistry Lab

1. Microscopy
2. Cell motility and flagellar staining, Photography and videotaping (motility, morphometry)
3. Micrometry: Calibration of stage and ocular micrometer and measurement of the given biological sample.
4. Haemocytometer: calibration and measurement of biological samples.
5. Cryo preservation of cells and recovery of frozen stocks into cultures.
6. Passaging of cells
7. Gram staining, Giemsa, Trypan blue staining.
8. Introduction to measurements: balances and pipetting Preparation of solutions of given normality and its standardization
9. pH meter: preparation of buffers of different capacity
10. Colorimetry: To determine the dissociation constant of a given indicator colorimetrically and to prepare the buffer solutions in the pH range of 2.2 to 8.0
11. Chemical analysis of water
12. Thin layer chromatography: lipids, mixture of dyes
13. Spectrophotometry: Analysis of glucose, sucrose and ethanol
14. ELISA Reader and spectrophotometer: Estimation of protein by Lowry, Biuret and Bradford methods
15. Enzyme assays
16. Protein estimation.

SBT 1006 Microbiology Lab

1. Cleanliness, media preparation, sterilization, culturing methods, dilution techniques, and isolation of pure cultures – techniques.
2. Staining techniques in microbiology i) simple staining ii) negative staining iii) positive staining iv) spore staining v) capsule staining and identification.
3. Culture characteristics of microbes, identification of unknown bacteria by biochemical tests.
4. Bacterial growth curve – serial dilution plating and turbidity measurement.

5. Competent cell preparation, replica plating.
6. Extracellular enzymatic activities of microbes, immobilization of *Sacchromyces cerevisiae* and alcohol.
7. Standard qualitative analysis of water.
8. Antibiotic sensitivity test, LD50, Potency of drugs/antibiotics and biotransformations.

Breadth Paper 1

Semester-II

SBT 2001 Enzyme Technology

Module 1:

Discovery, classifications and nomenclature of enzymes. Enzyme isolation. Enzyme assay, Intracellular localization of enzymes. Isozymes, Multienzyme complex, and multifunctional enzymes.

Module 2:

Enzyme kinetics and kinetics of enzyme inhibition. Competitive, non-competitive and uncompetitive inhibition of enzymes. Double reciprocal plots. Effect of PH, temperature, substrate and enzyme and inhibitors concentration on enzyme kinetics. Phenomena of allosterism and allosteric kinetics.

Module 3:

Enzyme memory and mnemonic enzymes. Mechanism and action of chymotrypsin, glyceraldehyde, 3-phosphate dehydrogenase, lysozyme, carboxypeptidase, ribonuclease, aldolase and ribozyme.

Module 4:

Molecular structure and function of enzymes. Physico-chemical characterization of enzymes. Folding and active site formation in enzymes. Stability of enzymes: Enzyme stabilization by selection and genetic engineering, protein engineering, reaction environment rebuilding.

Module 5:

Techniques used in the purification of the enzymes. Criteria of enzyme homogeneity, Techniques used for determination of native and sub-unit molecular weight of enzymes.

Module 6:

Bio-separations in enzymology: solid-liquid separation (filtration, centrifugation, membrane, flocculation), extraction, concentration (reverse osmosis, ultrafiltration), drying, instrumentation (GC/HPLC).

Module 7:

Enzyme immobilization, production and application of free and immobilized enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics.

Textbooks:

- 1 Godfrey and West, Industrial enzymology
- 2 Dordick, Biocatalyst for industry.

- 3 Bommarius, A.S. et al., Biocatalysis: Fundamentals and Application- Wiley Publication
- 4 Hans Bisswanger, Enzyme Kinetics- Wiley Publication
- 5 Methods in Enzymology- A series.

SBT 2003 Molecular Biology & rDNA Technology

Module 1:

Genetic organization: DNA as genetic material, structure of DNA, DNA replication, repetitive DNA, kinetics of DNA renaturation.

Module 2:

Gene Regulation: Discovery and salient features of genetic code, organellar genetic code, colinearity of genes and protein, General properties and types of mutation, DNA damage and repair, Protein synthesis, Posttranslational modifications

Module 3:

Regulation of gene activity: Central dogma, difference in genetic organization of prokaryote and eukaryote, *lac* operon, *trp* operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins, RNA synthesis, RNA processing and RNA editing, Small Double stranded RNAs and RNA interference

Module 4:

Methods In Genetic Engineering: Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique, Inverse PCR, Nested PCR, RACE PCR, RealTime PCR, Site directed mutagenesis, Restriction and modifying enzymes

Module 5:

Creation Of Recombinant Molecules: Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method.

Module 6:

Libraries: Genomic, cDNA, EST, Cot-based, Screening of libraries with DNA probes and with antisera. Large insert genomic libraries and physical mapping Strategies and approaches to genome sequencing

Module 7:

Applications Of Recombinant DNA Technology: Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis, Safety guidelines of recombinant DNA research.

Books Recommended:

1. Old and Primorose- Gene Manipulation
2. Alberts et al, Molecular Biology of the Cell
3. Watson, Recombinant DNA.
4. Lodish et al, Molecular Cell Biology.

SBT 2005 Bioprocess Technology**Module 1:**

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 behavior, kinetics of product formation.

Module 2:

Mass balance and yield concepts: Yield and maintenance coefficients, calculation based on elemental balances, degree of reduction, theoretical predictions of yield coefficients.

Module 3:

Enzyme kinetics: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for more complex enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems, brief introduction to large scale enzyme production.

Module 4:

Media and air sterilization: introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters.

Module 5:

Agitation and aeration: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_{La}), measurement of k_{La} , power requirement for agitation in gaseous and non gaseous systems.

Module 6:

Operating considerations for bioreactors: Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors:

Module 7:

Scale up, operation and control of bioreactors: Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control.

Books Recommended:

1. Lee, Biochemical Engineering
2. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
3. Aiba and Humphary. Biochemical Engineering
4. Doran, Bioprocess Engineering Principles
5. Bailey and Ollis, Biochemical Engineering Fundamentals

SBT 2007 Bioinformatics

Module 1: Major Information Resources & Databases in Bioinformatics

Information Resources: NCBI, EBI, ExPasy, Entrez, Derived (Secondary) Databases of Sequences, Different Biosequence File Formats.

Module 2: Sequence Alignment:

Similarity, Identity, Homology, Selectivity/Sensitivity, Linear and Affine Gap Penalty, Basics of Scoring matrices (PAM, BLOSUM), Dot matrix method, Dynamic programming using Needleman-Wunsch algorithm, CLUSTALW/X tool.

Module 3: Multiple Sequence Analysis:

Scoring methods of MSA (Sum of Pair), BLAST and FASTA, Theory and Algorithms, motif analysis and presentation.

Module 4: Phylogenetic Analysis:

Molecular Phylogenetics: Basics, molecular clock, Substitution Models of evolution, Tree reconstruction methods (Distance based)

Module 5: Molecular Modeling:

Structure alignment: superimposition and RMSD calculations, DALI, Classification of 3-D structures of proteins, SCOP, CATH

Module 6: Molecular Modeling and drug designing:

3-D Structure Prediction of Protein Structure (Chou-Fasman), Molecular Docking: Methods, Cheminformatics: Basic Concepts.

Module 7: Applications of Bioinformatics:

Next generation sequencing (DNA) techniques, Microarray - Data analysis, principles of homology and motif identification (DNA and protein).

Textbook

1. **Bioinformatics: Sequence and Genome Analysis**, David W Mount, Cold Spring Harbor Laboratory Press, New York (September 2004)
2. **Guidebook on Molecular Modeling In Drug Design (Illustrated)**, J. G. Vinter, Mark Gardner (Editor), J. G. Vinter (Editor), CRC Press (May 1994) ISBN: 0849377722
3. **Binformatics: a practical guide to the analysis of genes and proteins**, Baxevanis A., Ouellette F.B.F., John Wiley and Sons, New York.

SBT 2002 Enzyme & Bioprocess Technology lab

1. Sterilization of inlet and outlet air filters by steam.
2. *In situ* Sterilization of empty bioreactor.
3. Medium preparation and in situ sterilization of medium in the bioreactor.
4. Study of induction effect of galactosidase enzyme in *E. coli*.
5. Fermentation of ethyl alcohol using *Candida albicans*.
6. Fermentation of citric acid using *Aspergillus niger*
7. Creation of auxotrophic mutants for lysine, valine and other essential amino acids.
8. Designing of fermentation processes for penicillin and 6- APA.
9. Designing of fermentation process for lysine
10. Yeast fermentation to produce ethanol.
11. Fermentation of *Penecillium crysogenum* to produce penecillin
12. Determination of volumetric oxygen transfer coefficient (k_{LA}) by sulphite oxidation method.
13. Determination of volumetric oxygen transfer coefficient (k_{LA}) by dynamic method.

SBT 2004 Molecular Biology & rDNA Technology lab

1. Isolation and purification of genomic DNA from bacteria and plant tissues.
2. Isolation and purification of plasmid DNA.
3. Analysis of DNA by agarose gel electrophoresis.
4. Recovery of DNA from gels.
5. Restriction analysis of DNA.
6. Isolation, fractionation and purification of protein samples.
7. Analysis and detection of proteins by native and denaturing (SDS) polyacrylamide gel electrophoresis.
8. Spectrophotometric estimation of DNA, RNA and proteins.
9. Bacterial transformation and analysis of transformants.
10. Isolation of RNA
11. Electrophoresis of RNA on denaturing gels.
12. PCR technique

Breadth Paper 2

Semester-III

SBT 3001 Immunotechnology

Module 1:

Introduction: brief history of Immunotechnology, immune system, components of immune system, Innate and adaptive immune system, external and internal barriers, phagocytosis. Antigen clearance mechanism.

Module 2:

The antigens and antibodies, immunogenicity, MHC, cell-mediated and humoral immunity, effector mechanism.

Module 3:

Immunodeficiency, animal models of immunodeficiency, Diagnosis, therapeutic approaches.

Module 4:

Kinetics of Antigen antibody interaction, thermodynamics, different mathematical, Models of antigen antibody interaction with single and multiple binding sites.

Module 5:

Techniques in Immunotechnology, Blood groups: AB, Rh system, Precipitin curve, Immuno diffusion, Immuno electrophoresis, Agglutination, Widal test, Radioimmunoassay: ELISA, Immuno fluorescence, comet assay, FACS.

Module 6:

Antibody engineering, antigen engineering, vaccine production, Catalytic antibodies, antibody immunotherapy, productions of drugs to allergies. Hybridoma technology.

Module 7:

Reactor system for Production of Polyclonal antibodies , antigen preparation and modification, adjuvants, dose and route of antigen administration, collection of sera, purification of antibodies Production of cellular chemicals like Interferons, Interleukin etc.

Recommended Books:

1. Kuby J, Immunology, WH Freeman & Co., 2000.
2. Tizard, Immunology, fourth edition, Thomson Asia pvt. Ltd, 2004.
3. Talwar G.P., and Gupta S.K., “A hand book of practical and clinical immunology”, Vol. 1 & 2, CBS Publications, 1992.

4. Weir D.M., "Practical Immunology", Blackwell Scientific Publications, Oxford, 1990.
5. Immunology at a glance J.H.L. Playfair 4th edn. Blackwell scientific publication 1987.
6. Harper's Biochemistry (Latest edition)
7. Biotechnology by RC Dubay (2001) S Chand and Company, New Delhi.

SBT 3003 Environmental Biotechnology

Module 1:

Introduction to environmental biotechnology: Scope and importance - microorganisms and energy requirements of mankind - production of non conventional fuels-methane (biogas), hydrogen, alcohols and algal hydrocarbons and microbial fuel cells.

Module 2:

Bioremediation: Bioremediation, constraints, advantages and application, types of bio remediation (natural and Engineered), bio-attenuation, ex-situ & in-situ, bio-augmentation and bio-stimulation, application, specific advantages and disadvantages of specific bioremediation technologies. Land farming, prepared beds, biopiles, composting, bioventing, pump and treatment method, phytoremediation.

Module 3:

Mining and metal biotechnology: Microbial transformation, accumulation and concentration of metals, metal leaching, extraction and future prospects.

Module 4:

Micro-organisms as food: Microbial production of food (scp), essential prerequisites for organisms to be used as scp & as food and feed supplements. Microbial production of flavors and food colorants, probiotics & prebiotics.

Module 5:

Biological control: Microbial control of plants, plant pests, (bacteria, viruses, fungi and protozoa), pathogens and insects. Micro-organisms and microbial products.

Module 6:

Microbial biosensors: Definition, advantages and limitations, different components of a biosensor. Types of biosensors, Various transducer principles (conductometric, potentiometric, amperometric and optical detector)- specific biosensors- glucose, ammonia, bod, methane and mutagen sensors.

Module 7:

Biotechnology and intellectual properties: Intellectual property rights (IPR) and protection (IPP), patents, trade secrets, copyrights, trade marks, GATT and TRIPS. Elements of preparation of TKDL (Traditional Knowledge Digital Library, convention on biodiversity).

Text:

- Fundamentals of ecology: M. C. Dash, TMH Publication
- Text Book of Environmental Biotechnology, Pradipta Kumar Mohapatra

References:

- Ecology, Odum
- Environmental Chemistry, AK De
- Environmental Biotechnology, BD Singh
- Wastewater Engineering, Metcalf and Reddy

SBT 3005 Biosafety, Bioethics and IPR**Module 1:**

Biosafety: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals.

Module 2:

Biosafety guidelines: Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including; Cartagena Protocol.

Module 3:

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

Module 4:

Introduction to Intellectual Property: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Module 5:

Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments.

Module 6:

Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications:

Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet (EPO), PATENT Scope (WIPO), IPO, etc.)

Module 7:

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

Texts book:

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

SBT 3007 Plant Biotechnology

Module 1:

***In Vitro* culture:** Applications: benefits and limitations, Culture media components, role of plant growth regulators, sterilization techniques, aseptic manipulation techniques.

Module 2:

Callus Culture and Cyto-Differentiation: Callus cultures, differentiation and dedifferentiation, Organogenesis and Embryogenesis, Clonal/Micro Propagation, Somaclonal Variation, Artificial Seeds. Development of crops adaptable to environmental stresses, diseases and pests.

Module 3:

Cell Suspension: Development of cell suspension, Cell Cycle Synchronization, Mutation Selection, Production of Secondary Metabolites Plant Bioreactors, Bio-transformation, Long-term storage of cultures.

Module 4:

Protoplast Culture: Protoplast isolation, purification, plating; and regeneration, Protoplast Fusion, Somatic Hybrids and Cytoplasmic Hybrids.

Module 5:

Overcoming Barriers using Tissue Culture: Pre- and Post-Fertilization barriers, Production and use of Haploids. Germplasm conservation and cryopreservation

Module 6:

Transgenic Plants: Vectors and *Agrobacterium* mediated-techniques used, Genetically Modified value added speciality crops and social issues, Resistance against Biotic and Abiotic

Stresses, Molecular farming and plants as factories for biopharmaceuticals, Engineering and Transformation of Chloroplast Genome.

Module 7:

Molecular Markers: Comparison of different types of markers:- RFLP, RAPD, AFLP, AP-PCR, STS, EST, SNP, DNA Microarray; Construction of Molecular Maps

Books Recommended:

1. A. Mizrahi, Biotechnology in agriculture
2. S. Natesh, Biotechnology in agriculture
3. Dixon and Gonzales, Plant cell culture – a practical approach.
4. Razdan, An introduction to plant tissue culture.

SBT 3009 Animal biotechnology

Module 1:

Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures.

Module 2:

Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence, cell-cell communication, cell senescence.

Module 3:

Cell Culture Lines: Definition, development and maintenance, cloning of cell lines, cell synchronization viral sensitivity of cell lines, cell line preservation and characterization, stem cell lines.

Module 4:

General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explantation technique.

Module 5:

Organ Culture: Methods, behavior of organ explants and utility of organ culture, whole embryo culture.

Module 6:

Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection.

Module 7:

Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, Cloning for production of transgenic animals, cloning for conservation.

Books Recommended:

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

SBT 3011 Industrial Biotechnology

Module 1:

Technology of Microbial Cell Maintenance

Principles of Microbial growth, Methods to increase yield of microbes, Batch, fed-batch and continuous cultures (definition and kinetics). Strain preservation, maintenance and strain improvement by mutation of gene transfer processes. Microbial culture selection with high yield potential. Commercial Production of Microorganisms.

Module 2:

Bioreactor / Fermenter

Types & operation of Bioreactors, physico-chemical standards used in bioreactors, limitations of bioreactors, stages of fermentation processes, Media design for fermentation processes, Solid substrate fermentation, Fermenters (Stirred tank, bubble columns, airlift. Bioreactors, Static, Submerged and agitated fermentation), advantages & disadvantages of solid substrate & liquid fermentations.

Module 3:

Production of Primary Metabolites

A brief outline of processes for the production of some commercially important organic acids (e.g. citric acid, lactic acid, acetic acid etc.); amino acids (glutamic acid, phenylalanine, aspartic acid etc.) and alcohols (ethanol, butanol etc.)

Module 4:

Production of Secondary Metabolites

Study of production processes for various classes of secondary metabolites: antibiotics: beta-lactams (penicillin, cephalosporin etc.), aminoglycosides (streptomycin etc.) macrolides (erythromycin), vitamins and steroids.

Module 5:

Production of Enzymes and other Bioproducts

Production of industrial enzymes such as proteases, amylases, lipases, cellulases etc., Production of biopesticides, biofertilisers, biopreservatives (Nisin), cheese, biopolymers (xanthan gum, PHB etc.), single cell protein.

Module 6:

Bioconversions and Bioremediation

Biomining and bioleaching of ores, Ethanol from biomass, methane from biomass, hydrogen, Biodiesel, Algal Biofuel. Bioremediation of oil spills using biosurfactants. Wastewater treatment, Removal of heavy Metals, Microbial degradation of pesticides and aromatics compound, microbial biopolymers.

Module 7:

Production Modern Biotechnology Products

Production of recombinant proteins having therapeutic and diagnostic applications, production of vaccines. Production of monoclonal antibodies. Products of plant and animal cell culture.

SBT 3013 Pharmaceutical Biotechnology

Module 1:

Introduction and history of pharmaceutical Biotechnology: Overview of bioproducts in health care- Biologicals, Vaccines, Enzymes, Therapeutics and Diagnostics products and Services.

Module 2:

Genomics and its impact on medicine: Rational drug design processes-introduction to QSAR, 3-D QSAR; genetic counseling and gene testing; cancer- oncogenes, tumor suppressor genes and growth factors. Hereditary disorders, Single nucleotide polymorphism (SNP) and its application in molecular medicine and personal medicine,

Module 3:

Pharmacogenomics and gene therapy: Pharmacogenomics based approaches for cancer and diabetes; Principles, methods and applications of gene therapy, viral, non-viral systems for gene therapy, gene therapy case studies – Inborn errors and hematopoietic disorders.

Module 4:

Production of therapeutic macromolecules: products from Biopharming, Hybridoma technique, fermentation and cell and tissue cultures. Genetically engineered pharmaceuticals: such as recombinant insulin, growth hormone, hepatitis B vaccine and interferon.

Module 5:

Diagnostic biotechnology: Design and development of ELISA kit, monoclonal antibodies in disease detection and treatment, Immunological reagents, role of PCR in microbial, plant and animal cell/virus detection.

Module 6:

Regenerative Medicine: Tissue engineering- Characteristics of cells involved in tissue engineering, Types of biomaterial used, method and applications. Stem cell therapy- Definition, scope, types of stem cells, methods and applications.

Module 7:

Biotechnology industry requirements: Handling of raw materials and biomaterials, Layouts of a biotech/solvent production plant, GMP (Good Manufacturing Practices), Stability of the prepared bioproducts, concept of expiry date, r-DNA Products and Ethical Issues.

Books Recommended:

1. Maulik and Patel, Molecular Biotechnology – Therapeutic applications and strategies.
2. Zito, Pharmaceutical Biotechnology.

SBT 3015 Computational Biology

Module 1: Systems Biology-I

Statistical modeling: Log-likelihood, Maximum-likelihood and Expectation Maximization, Bayesian network, Markov and Hidden Markov Models (HMM),

Module 2: Systems Biology-II

Applications of HMM in gene identification and Profiles HMMs, Machine learning: Artificial-Neural Network, Support vector machine, Genetic Algorithms

Module 3: Metabolic network modeling

Databases (KEGG, BioCyc, MetaCyc, ENZYME, BRENDA, BiGG), Pathway Tools (ERGO, Metamerge, Model SEED), Methodology to draft a metabolic pathways reconstruction, Model Refinement and simulation, Metabolic control analysis, Applications of a reconstruction

Module 4: Molecular Modelling

Molecular Mechanics: Concepts of Force-field, PE representation, Energy minimization techniques, Molecular Dynamics (Optimization algorithms: Steepest descents, Conjugate gradient)

Module 5: Molecular Docking

Molecular Docking: Methods and Scoring Functions

Module 6: Cheminformatics

Rational Drug Designing (CADD)

- a. Computer-aided identification, characterization, and comparative analysis of binding sites in target proteins.
- b. Development of pharmacophores based on ligand and/or receptor structures.
- c. Analysis and prediction of protein-ligand complexes: database searching, docking, and design.
- d. Quantitative assessment of binding interactions: free energy calculations and scoring functions

Module 7: Biosequence Analysis

Genome sequencing strategies, Genome assembly, Gene identification methods, Proteins Arrays and Protein Chips, Single nucleotide polymorphisms, Genomics in drug discovery, in silico Protein Identification and Analysis

Textbooks:

1. Brian W. Kernighan and Rob Pike, The UNIX Programming Environment, Pearson Education (Indian reprint, 2003) ISBN: 81-297-0074-3.
2. Kernighan, Brian W. and Dennis M. Ritchie. 1988. The C Programming Language. 2nd ed. Prentice Hall PTR.
3. T.H. Cormen, C.E. Leiserson, and R.L. Rivest, Introduction to Algorithms, The MIT Press, Cambridge, Massachusetts, USA, 1990
4. James Tisdall, Beginning Perl for Bioinformatics: An Introduction to Perl for Biologists, O'Reilly Media
5. James L. Antonakos and Kenneth C. Mansfield, Practical Data Structures Using C/C++, Prentice Hall (1999) ISBN: 01-302-6864-X.
6. David W. Mount (2001) Bioinformatics: Sequence and Genome Analysis. Cold Spring harbor Press
7. A.R. Leach: Molecular Modelling. Longman Singapore Publishers 1996

SBT 3017 Genomics & Proteomics

Module 1:

Genome Organization: Chromosome structure and function, Chromatin organization and its packaging, physico-chemical properties of Nucleic Acids, DNA as genetic material, Central dogma of molecular biology

Module 2:

Regulation of gene activity: DNA replication and transcription, difference in genetic organization of prokaryote and eukaryote, *lac* operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins, discovery and salient features of genetic code, organellar genetic code, colinearity of genes and protein

Module 3:

PCR and Its Applications: Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; Overlap extension; and SOEing; PCR in molecular Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

Module 4:

DNA sequencing: Sanger and different Next generation sequencing techniques, Genome sequencing strategies, sequence assembly, Gene identification methods, Genome annotation techniques, Comparative genomics Single nucleotide polymorphisms

Module 5:

Creation Of Recombinant Molecules: Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method, Genomic, cDNA, EST and Large insert DNA libraries

Module 6:

Forward and Reverse genetics Post-Transcriptional Gene silencing: RNA interference, antisense RNA, siRNA, MiRNA, Genomics in drug discovery

Module 7:

Gene expression: Microarray - the technique, Experimental design & Data analysis, Application of Microarray, Proteins Arrays and Protein Chips, Real-Time PCR based gene expression, RNAseq and Tag-based transcriptome wide gene expression study

Textbook

1. *Principles of Genome analysis and Genomics*, 3re Edition, S. B. Primrose and R. L. Twyman, Blackwell publishing (2003) ISBN: 1405101202
2. *Proteomics: From Protein Sequence to function*, S R Pennington and M J Dunn. New York: BIOS Scientific Publishers, 2001.
3. *Bioinformatics and Functional Genomics*, Jonathan Pevsner, Wiley-Liss

SBT 3019 Bio Analytical Techniques

Module 1:

Centrifugation Techniques: Introduction, basic principle of sedimentation, basic idea of types of centrifuges, density gradient centrifugation, preparative centrifugation, analysis of subcellular fractions, & applications of analytical centrifugation.

Module 2:

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

Module 3:

Chromatographic Techniques – II: (a) Gas Chromatography: Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. (b) HPLC: Principle, components of HPLC system, pumping systems, detectors systems, and its applications; UPLC.

Module 4:

Electrophoresis: (a) General principle, factors affecting electrophoresis – voltage, current, resistance, buffer – composition, concentration, pH. (b) Gel electrophoresis; Types of gels (starch, agarose, polyacrylamide), Idea of electrophoresis unit, preparation of gel, sample application, running the samples, SDS-PAGE - Principle, apparatus and methods, gradient gels, Two dimensional gels, isoelectric focusing.

Module 5:

Spectroscopy – I: (a) Spectroscopic Techniques; Introduction, Energy levels and transition of electrons, Types of spectra, Beers Lamberts law, molar and extinction coefficient. (b) Visible and UV Spectrophotometry; Principles, Instrumentation and applications. (c) Spectrofluorimetry; Principle, stoke's shift, quantum efficiency, instrumentation, & applications

Module 6:

Spectroscopy – II: (a) Atomic & Flame spectrophotometry ; Principles, Instrumentation & applications for flame emission / atomic absorption spectrophotometry and their comparative study; ICP (b) Mass spectrometry; Principles, Instrumentation and applications

Module 7:

Thermal Analysis: Differential scanning calorimetry and differential analysis - Instrumentation, Thermogravimetry, Methodology of Thermogravimetry, differential scanning calorimetry and differential thermal analysis.

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.

SBT 3021 Downstream Processing

Module 1:

An overview of Recovery processes; Characteristics of biological products; Problems and requirements of bio-product purification processes; Costing and cost cutting strategies.

Module 2:

Primary Separation and Recovery Process: Removal of microbial cells and other solid matters, Coagulation, Flocculation, Filtration and Filtration; Conditioning of broth. Cell disruption techniques; Mechanical and non-mechanical methods (Theory, Design and Configuration of the Equipment).

Module 3:

Isolation of Product: Extraction and Adsorption methods, Solid- Liquid , Liquid -liquid Separation, Distillation; Enrichment operation-Membrane based Separation -micro and ultrafiltration (Theory, Design and Configuration of the Equipment); Precipitation methods using - Ammonium Sulphate, Organic Solvents, High molecular weight polymers. Protein precipitation and separation, Aqueous- two- phase extraction.

Module 4:

Product Purification: Chromatography principle for product purification. Column Chromatographic methods of separation based on size, charge, hydrophobic interactions and biological affinity. TLC, GLC and HPLC.

Module 5:

Product Purification: Electrophoresis and Membrane based separation; Types of membrane and filtration mechanism, Dialysis, Electrodialysis; Microfiltration, Ultrafiltration, Isoelectric focussing, Electrophoresis.

Module 6:

Alternative Sepatation methods: in situ recovery, Supercritical extraction, Reverse micelles extraction, Pervaporation.

Module 7:

Finishing Operations: Crystallization; Drying; Introduction to packaging with special reference to fermentation products.

Texts/References:

1. E L V Harris and S. Angal, Protein Purification Methods, Ed. IRL Press at Oxford University Press, 1989.

2. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication, 1988.
3. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.
4. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.

SBT 3002 Immunotechnology lab

1. Immunodiffusion
2. Immunoelectrophoresis
3. Western blotting
4. Production of monoclonal antibodies and testing,
5. Antigen – Antibody reactions (Widal test, Blood grouping, Rh factor)
6. RBC & WBC count by haemocytometer
7. ELISA

SBT 3004 Environmental Biotechnology lab

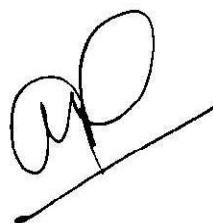
1. Physico-chemical and biological characterization of wastewater.
2. Determination of total solids, total dissolved solids, total suspended solids, volatile solids, fixed solids/ash content and moisture content in solid waste and wastewater.
3. Determination of MLVSS.
4. Determination of sludge volume index and food to microorganisms.
5. Determination of Kjeldahl nitrogen, nitrate and nitrite nitrogen.
6. Determination of inorganic phosphates by Technicon analyzer.
7. Determination of organic carbon, nitrogen and sulphur by NCS analyzer.
8. Determination of various metals present in waste and wastewater samples.
9. Determination of BOD of wastewater samples.
10. Determination of COD of wastewater samples.
11. Enumeration of contaminating pathogenic organisms.
12. Various sampling techniques for collecting air samples.

Semester- IV

SBT 4001 Project & Comprehensive Viva

Semester- IV .

SBT 4001 Project & Comprehensive Viva

A handwritten signature in black ink, consisting of stylized loops and a long horizontal stroke at the bottom.

Semester/ Session of Study (Recommended)	Course Level	Category of course	Course Code	Courses	Mode of delivery & credits <i>L-Lecture; T-Tutorial; P-Practicals</i>			Total Credits <i>C-Credits</i>	
					L (Periods/ week)	T (Periods/ week)	P (Periods/ week)	C	
	THEORY								
FIRST Monsoon	FIRST	FS Foundation Sciences	MA103	Mathematics - I	3	1	0	4	
			PH113	Physics	3	1	0	4	
		GE General Engineering	EE101	Basics of Electrical Engineering	3	1	0	4	
			CS101	Programming for Problem Solving	3	1	0	4	
	LABORATORIES								
	FIRST	FS	PH114	Physics Lab	0	0	3	1.5	
			GE	CS102	Programming for Problem Solving Lab	0	0	3	1.5
			GE	PE101	Workshop Practice	0	0	3	1.5
			MC Mandatory Course	MC101/102/103/ 104	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1
	TOTAL								21.5
SECOND Spring	THEORY								
	FIRST	FS	MA107	Mathematics - II	3	1	0	4	
			CH101	Chemistry	3	1	0	4	
		GE	ME101	Basics of Mechanical Engineering	3	1	0	4	
			EC101	Basics of Electronics & Communication Engineering	3	1	0	4	
	LABORATORIES								
	FIRST	FS	CH102	Chemistry Lab	0	0	3	1.5	
			GE	EC102	Electronics & Communication Lab	0	0	3	1.5
		MC	ME102	Engineering Graphics	0	0	4	2	
			MC105/106/107/ 108	Choice of : NCC/NSS/ PT & Games/ Creative Arts (CA)	0	0	2	1	
TOTAL								22	
GRAND TOTAL FOR FIRST YEAR								43.5	

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)

[illegible]

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							
EIGHTH Spring	FOURTH	PC	BE400	Research Project / Industry Internship	Total			12
GRAND TOTAL <i>Minimum requirement for Degree award</i>								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**

Semester/ Session of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Prerequisite/ Corequisite	Mode of delivery & credits <i>L-Lecture; T-Tutorial; P-Practicals</i>			Total Credits <i>C- Credits</i>
						L (Periods/w eek)	T (Periods/w eek)	P (Periods/w eek)	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)

Recommended scheme of study

Semester/ Session of Study (Recommended)	Course Level	Category of Course	Course Code	Courses	Prerequisite/ Corequisite	Mode of delivery & credits <i>L-Lecture; T-Tutorial; P-Practicals</i>			Total Credits <i>C- Credits</i>
						L <i>(Periods/w ee k)</i>	T <i>(Periods/w ee k)</i>	P <i>(Periods/w ee k)</i>	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			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

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:

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

Syllabus

Credit:2

CE101 ENVIRONMENTAL SCIENCE

Module-1: Ecosystem and Environment: [6L]

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: [8L]

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: [8L]

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: [8L]

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, composting, pyrolysis.

Module- 5: Noise pollution & Radioactive pollution: [8L]

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 Saunders 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
Assignment / Quiz (s)	10+10
Teacher's Assesment	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: MA 203

Course title: Numerical Methods

Pre-requisite(s): NIL

Co- requisite(s): —NIL

Credits: 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

CO 1	solve algebraic and transcendental equation using an appropriate numerical method arising in various engineering problems
CO 2	solve linear system of equations using an appropriate numerical method arising in computer programming, chemical engineering problems etc.
CO 3.	Approximate a function using an appropriate numerical method in various research problems
CO 4	evaluate derivative at a value using an appropriate numerical method in various research problems
CO 5	solve differential equation numerically

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]

Text Books:

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, PIII.
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

Assessment components	CO1	CO2	CO3	CO4	CO5
Mid semester examination	√	√	√		
End semester examination	√	√	√	√	√
Quiz (s)	√	√	√		
Assignment	√	√	√	√	

Indirect assessment –

1. Student feedback on course outcome

Mapping of course outcomes onto program outcomes

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

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

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

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 & 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: IIIrd
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 Assesment	5

Assessment Compoents	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	x		x									
2	x	x	x									
3	x		x		x							
4	x					x			x	x		
5		x	x			x		x				
6				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, 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: [8]
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: [8]
Cell structure and major characteristics of cellular (bacteria, fungi, algae, protozoa) and acellular (viruses) organisms, Archaeobacteria, Growth of Microorganisms: Nutritional and physical requirements, Batch culture, Continuous culture, Synchronous growth, Fed-batch culture

Module-III: Environmental & Industrial Microbiology: [8]
Water treatment, Bacteriological analysis of water, Bioleaching, Bioremediation, Industrially important micro-organisms and secondary metabolites.

Module-IV: Agricultural Microbiology: [8]
Plant-microbial interactions, Biodeterioration of agricultural products, control of microbes and safe storage of agricultural products/food.

Module-V: Medical Microbiology: [8]
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	X					X						
2	X		X		X	X						
3	X		X			X						
4	X		X			X						
5			X			X						
6		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	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:

[8]

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:

[8]

Glycolysis, Gluconeogenesis, Krebs'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: [8]
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: [8]
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: [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.

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 Assesment	5

Assessment Compoents	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	x		x									
2	x	x	x	x	x							
3	x	x	x		x	x			x			
4	x					x			x	x		
5		x	x			x		x				
6				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	CD1, CD2, CD3, CD8

CD2	Tutorials/Assignments	CO2	CD1, CD2, CD3, CD8
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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 Modeling (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	x	x		x			x					
CO2	x		x		x							
CO3								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 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

1. Write a program in python to transpose a given matrix $M = \begin{bmatrix} 1 & 2 \\ 4 & 5 \\ 3 & 6 \end{bmatrix}$.

2. 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 $\sqrt{2-x^2}$ over the interval $-3 \leq x \leq 3$ and $-3 \leq y \leq 3$.

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 $\theta = 60^\circ$ 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:

$$1 + 2 + 3 + 4 + \dots + 12$$

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.

1	2	3;
4	5	6;
7	8	9;
10	11	12;

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 the 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.

6. Integrate the polynomial $y = 4x^3 + 12x^2 + 16x + 1$. 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 $x = t^2$ and $y = 4t$ for $-4 < t < 4$. Using MATLAB obtain a 3-D plot showing the matrix in (x, y) space as a function 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 $ax^2 + bx + c = 0$, 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: 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", 6th Edition, Prentice Hall Inc., 2003
- T2.** Felder, R. M. and Rousseau, R. W., "Elementary Principles of Chemical Processes", 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	x	x	x	x	x							
2			x	x	x				x	x		
3		x	x						x	x		

4			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	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.

SYLLABUS

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 (1 L)

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-Culloch 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. Madiseti Vijay and Bahga Arshdeep, Internet of Things (A Hands-on-Approach), 1st Edition, VPT, 2014.(T1)
- 3 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.

Reference Books:

- 4 Raj Pethuru and Raman Anupama C.,The Internet of Things: Enabling Technologies, Platforms, and Use Cases, CRC Press. (R1)

- 4 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 through 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
End SEM Examination Marks	60
Assignment / Quiz (s)	15

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	Program Outcomes

Outcome	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: BE207
 Course title: Cell Biology & 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 Sem
 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 knowledge 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.

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: 3
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 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, Immunoelectrophoresis, 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 Assesment	5

Assessment Compoents	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	x	x										
2	x		x	x	x							
3	x				x		x					
4		x		x			x	x				
5						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	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, filmwise 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 Assesment	5

Assessment Compoents	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	x	x	x	x	x	x						
2		x	x	x	x							
3		x	x					x	x	x		
4		x	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: 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 Macroscopic 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-Standard 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 Homogeneous 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. Stephanopoulos 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 internet
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 title: Electrical Engineering Laboratory

Pre-requisite(s): Physics, Fundamentals of Mathematics and Electrical Engineering.

Credits: L:0 T:0 P:3

Class schedule per week: 3

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

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
evaluation (60) Regularity/Punctuality:	Progressive 10
Assignment:	10
Practical examinations:	20
End sem Viva-voce	: 20
(40)	end evaluation
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: 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 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 Assesment	5

Assessment Compoents	CO1	CO2	CO3	CO4
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	√	√	√	√	√	√	√	√		√	√	√

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,CD7
CD2	Tutorials/Assignments	CO2	CD1, CD5,CD7
CD3	Seminars	CO3	CD1, CD5,CD7
CD4	Mini projects/Projects	CO4	CD1, CD5,CD7
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 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

S. No	Name of Experiments
Experiment -1	To obtain the Reynolds number in different flow conditions.
Experiment -2	To calibrate Venturimeter 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 vortex.
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 INFORMATION SHEET

Course code: BE213

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Course title: Pharmaceutical Biotechnology**Pre-requisite(s):****Co- requisite(s):****Credits:** 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 pharmacodynamics
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:

Molecular Biotechnology: Genomics and its impact on medicine. Molecular medicine, Rational drug design.

Module-2:

Gene Testing & Diagnostics: Gene testing, pharmacogenomics, Molecular diagnostics.

Module-3

Cancer Biology & Gene therapy: Oncogenes, tumor suppressor genes, growth factors, Genetic diseases and DNA based diagnosis of genetic diseases. Gene therapy.

Module-4:

Formulation of Biotech Products: Microbiological consideration, use of excipients, Drug delivery methods, Shelf life of biopharmaceuticals, pharmacodynamics of protein therapeutics.

Module-5:

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
End Sem Examination Marks	60
Assignment / Quiz (s)	15

Assessment Components	CO1	CO2	CO3	CO4	
Mid Sem Examination Marks					<u>25%</u>
End Sem Examination Marks					<u>60%</u>
Assignment					<u>15%</u>

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	x	x	x				
4							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	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:

Natural Substances: Sources, Cultivation and Production; Interrelationships of Drug Biosynthetic Pathways, Phytochemical classification of drugs.

Module-2:

Biosynthesis of Natural Product: Glycosides -shikimic acid and phenylalanine pathways, Terpenoids-Monoterpenoids, Alkaloids-Ephedrine, Biosynthesis of Phenylpropanoids via the Shikimic Acid Pathway

Module-3:

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:

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:

Biopharmaceuticals: Ginseng, Ephedrine, Artemisinin, 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				<u>2.5</u>	<u>2.5</u>
End Sem Examination Marks	8	12	10	10	10
Assignment / Quiz (s) (2 No.)	<u>4</u>	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	X					X						
2	X					X						X
3	X	X	X		X	X						X
4	X	X	X	X		X						
5	X	X	X	X		X	X	X			X	

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.

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/ 9th Intl Edn., Philadelphia, W.B. Saunders, 2001/2006.
- T2.** E.R. Kandel & J. Schwartz (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	x		x									
2	x	x										
3	x		x		x							
4	x	x	x			x						
5		x	x			x	x					
6		x	x				x	x	x	x		x

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 pharmaceuticals 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
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- 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	√	√	√	√	√	√	√			√		√
2	√	√	√	√	√	√	√	√		√	√	√
3	√	√	√	√	√	√	√	√		√	√	√

Mapping Between COs and Course Delivery (CD) methods			
CD	Course Delivery methods	Course	Course

		Outcome	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: BE2020

Course title: Biochemistry & Microbiology

Pre-requisite(s): Basics of Biological sciences

Co- requisite(s): Nil

Credits: L:3 T:1 P:0

Class schedule per week: 04

Class: B. Tech

Semester / Level: Vth

Branch: All

Name of Teacher:

Course Objectives

This course enables the students:

1.	Students will understand structures, properties and functions of the main types of biological macromoleculesproteins (including enzymes), carbohydrates and lipids.
2.	To outline the main pathways of metabolism in the cell: catabolic (breakdown)

	reactions yielding energy and anabolic (biosynthetic) reactions leading to the formation of new molecules within the cell.
3.	To impart knowledge about the catalytic role of enzymes, their structures, physico-chemical properties, mechanism of action, immobilization of enzymes and their applications
4.	To establish an understanding of the basic techniques (concept of aseptic work, cultivation and identification) in microbiology
5.	To describe role of microbes in environment, agriculture, food and pharmaceuticals
6.	To understand host-pathogen interactions in plant and animals, the prevention and control of infectious diseases.

Course Outcomes

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

CO1.	Recall the basic structures and functions of the main macromolecule classes (carbohydrates, proteins & lipids)
CO2.	Recall the basic principles of cellular energy (i.e. ATP, NAD ⁺) and metabolic pathways
CO3.	Outline the basic principles of enzyme catalysis
CO4.	Identify different microbiological techniques, define characteristics of the major groups of microorganisms and appreciate the vast diversity of the microbial world.
CO5.	Evaluate how microorganisms interact with the environment, plants and animals in beneficial or detrimental ways.
CO6.	Solving environmental, health and societal issues with the knowledge acquired

Biochemistry & Microbiology

Module I:

Structure and functions of Biomolecules (carbohydrates, amino acids, nucleic acids, lipids, vitamins), Stabilizing interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc).

Module II:

Carbohydrate Metabolism: glycolysis, gluconeogenesis, citric acid cycle, Electron transport chain, oxidative phosphorylation, glycogen metabolism, beta oxidation, photosynthesis (light & dark reactions).

Module III:

Enzymes: Nomenclature & classification, mechanism of enzyme action, effect of substrate concentration, Michaelis Menten equation, effect of pH, temperature on enzyme activity, Enzyme inhibition, Isoenzymes.

Module IV:

Techniques in Microbiology: Microscopy, Methods of sterilization; culture media, Pure culture methods, Staining of Bacteria, Micrometry, culturing cells and spores, Air sampling, Measurement of microbial growth

Module V:

Applied Microbiology: Industrial-microbial production of primary and secondary metabolites, fermentation; Environmental-Bioremediation, Bioleaching, water treatment; Agricultural-Bioinoculants, Microbial deterioration of agricultural products and methods of safe storage and Medical-Microbial flora of healthy human host, host – pathogen interactions in plant and animals

Text books: (T)

1. U. Satyanarayana & U. Chakrapani, Biochemistry, 4th Ed., Elsevier, 2013

2. Cohn and Stumpf, Outlines of Biochemistry, 5th Ed., Wiley, 2006
3. Robert M. Devlin, Plant Physiology, 4th Ed., PWS, 1983
4. Prescott, Harley, and Klein, Microbiology, 7th Ed., Tata McGraw-Hill, 2008.

Reference books: (R)

1. D. L. Nelson and M. M. Cox, *Lehninger Principles of Biochemistry*, 5th Ed., Macmillan Worth, 2007.
2. J. L. Tymoczko, J. M. Berg and L. Stryer, *Biochemistry*, 5th Ed., W. H. Freeman, 2002.
3. Pelczar, Chan and Krieg, Microbiology, 5th Edition, Tata McGraw-Hill, 1986
4. Frazier and Westhoff, Food Microbiology, 4th Edition, Tata McGraw-Hill, 1995

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✓
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	√	10				5
End Sem Examination Marks	√	√	√	√	√	√
Assignment*		√	√	√	√	√
Quiz I	√	√	√			
Quiz II				√	√	√
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	5	5	5	5		05

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

1	x		x									
2	x	x										
3	x		x		x							
4	x	x	x			x						
5		x	x			x	x					
6		x	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	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		
CD8	Self- learning such as use of NPTEL materials and internets		
CD9	Simulation		



Department of Electrical and Electronics Engineering
BIRLA INSTITUTE OF TECHNOLOGY
Mesra, Ranchi – 835 215

Minutes

Date: 16.01.2012

A meeting of the 'Board of Studies' of Center for Biomedical Instrumentation, Department of Electrical and Electronics Engineering was held on 16.01.2012 at 2.00 PM in Electrical Seminar Room. Following members attended to suggest and approve the course structure and syllabi of M. Tech in Biomedical Instrumentation.

Sl. No.	Name of Member	Designation	Signature
1	Dr. D. N. Tibarewala	Ex-Director, School of Bio-Science and Engineering, Jadavpur University	
2	Dr. S. K. Chaudhary	Superintendent, RIMS, Ranchi	
3	Prof. N. Gupta	Head, Dept. of ECE	
4	Prof. B. N. Sinha	Head, Dept. of Pharm. Sci.	
5	Prof. B. B. Das	Prof., Dept. of EEE	
6	Prof. R. C. Jha	Prof., Dept. of EEE	
7	Prof. D. K. Mohanta	Prof., Dept. of EEE	
8	Dr. P. R. Thakura	Asso. Prof., Dept. of EEE	
9	Dr. R. K. Sinha	Asso. Prof., Center for BMI, Dept. of EEE	
10	Mr. S. Kumar	Asst. Prof. Center for BMI, Dept. of EEE	
11	Mr. N. Singh	Student representative (Research)	

Business transacted: The attached course structure and syllabi are approved.

16.1.2012
for (Prof. & Head)
Dept. of EEE

Department of Bio- Engineering
Birla Institute of Technology, Mesra

COURSE CURRICULUM
(M. Tech. Biomedical Instrumentation)

1 st Semester	Course Code	Offering Dept./Center	Subject	L-T-P	Credit
	TMI 1001	BMI	Bioinstrumentation and Measurement	3-1-0	4
	MEC 1047	BMI	Sensors and Transducers	3-0-0	3
	TMI 1023	BMI	Anatomy and Physiology for Biomedical Engineers	3-0-0	3
	TMI 1003	BMI/EEE	Advance Signal Processing Techniques in Medicine/ <i>Breadth Paper</i>	3-0-0	3
			<i>Elective-1 (Any one)</i>		
	TMI 1005	BMI	Health Informatics and Telemedicine	3-0-0	3
	TMI 1007	BMI	Biomaterials and Artificial Organs	3-0-0	3
	TNT 1001	App Phy	Introduction to Nano Science and Nano Technology	3-0-0	3
	MPS 1101	Pharm Sci	Advanced Instrumental Analysis	3-0-0	3
			<i>Laboratory</i>		
	TMI 1002	BMI	Biomedical Equipment Design	0-0-3	2
	TMI 1004	EEE	Biomedical Signal Acquisition and Processing	0-0-3	2
			<i>Non-Credit (for non-Engineering Students)</i>		
	TMI 1021	BMI	Fundamentals of Electrical and Electronics Engineering	3-0-0	0
Total				22 H	20 C
2nd Semester					
	MEE 2115	EEE	**Embedded System and Application	3-0-0	3
	TMI 2001	BMI	Biomechanics and Human Factors Engineering	3-0-0	3
	TMI 2003	BMI	Medical Imaging Systems	3-1-0	4
	TMI 2005	BMI/ECE	Concept of Biomedical Image Processing/ <i>Breadth Paper</i>	3-0-0	3
			<i>Elective-2 (Any one)</i>		
	TMI 2007	BMI	Physiological Control Systems	3-0-0	3
	TMI 2009	BMI	Rehabilitation Engineering	3-0-0	3
	MEE 2121	EEE	Systems Biology	3-0-0	3
	TMI 2011	EEE	Artificial Intelligence Applications in Biomedicine	3-0-0	3
			<i>Laboratory</i>		
	TMI 2004	EEE	Biomedical Image Processing	0-0-3	2
	MEE 2116	EEE	Embedded System Application Lab.	0-0-3	2
Total				22 H	20 C
3rd and 4th Semester			Project Work		
	TMI 3001	BMI	3rd Semester		15
	TMI 3002	-----	Summer Training	0-0-0	00
	TMI 4001	BMI	4th Semester		20
Total Credits					75 C

****Advance Engineering Science Paper**

1st Semester
Theory

Bioinstrumentation and Measurement

(3-1-0)

(TMI 1001)

Module-1: Introduction to biomedical instrumentation: Category of measurement, factors in making measurement, biometrics, problems encountered in measuring a living system.

Module-2: Electrocardiography, Holter recorder, patient monitoring system, phonocardiography, blood pressure measurement, pulse plethysmography, pacemakers, defibrillators.

Module-3: Heart lung machine, extra corporeal membrane oxygenator, intra-aortic balloon pump, ventilators, anesthesia machine, capnograph, spirometry, pulmonary function analyzers, pneumotachometers. Hemodialysis machine.

Module-4: Electromyography (EMG), electroencephalography (EEG), evoked potentials analysis. Electroretinography (ERG), Electro-Oculography (EOG), perimetry testing, ophthalmoscopy, audiometry, otoscopy.

Module-5: Principle of colorimetry, photometry and pH measurement. Spectrophotometer; Spectrofluorometer; pH meter. Blood Cell counter; Biochemical analyzers; Na-K analyzer.

Module-6: Physiotherapeutic diathermies, nerve and muscle stimulator, electroshock therapy. Medical linear accelerator, Co60 Machine.

Module-7: Surgical diathermy, surgical laparoscopy, lithotripsy. Sterilization equipment.

Text Books

1. Handbook of Biomedical Instrumentation by R. S. Khandpur, Tata McGraw Hill
2. Introduction to Biomedical Technology by J. J. Karr & J. M. Brown
3. Medical Instrumentation by J. G. Webster

Reference Books

1. Biomedical Engineering Handbook by J. D. Bronzino

Resource Department/Center

1. Biomedical Instrumentation

Module-1: Introduction about sensors and transducers, Principles of operation and their classification, characteristics of sensors.

Module-2: Conventional sensors Type: Based on Resistive principles. Potentiometer and Strain Gauge. Based on Inductive principles- Ferromagnetic Plunge type, Inductance with a Shortcircuited sleeve. Transformer type, Electromagnetic Transducers. Based on capacitive principles- The parallel plate capacitive sensor, Variable Permittivity Capacitive Sensor, Stretched Diaphragm Variable Capacitive Transducer. Electrostatic and Piezoelectric Transducers, Quartz Resonators and Ultrasonic Sensors. Based on Magnetic principles. Magnetoresistive, Hall effect, Inductance and Eddy current sensors. Angular/Rotary movement Transducer, Electromagnetic Flowmeter, Pulse wire sensor and SQUID sensor.

Module-3: Thermal Sensors: Acoustic Temp Sensor, Nuclear Thermometer, Magnetic Thermometer, Resistance Change Type, Thermoemf, Junction Semiconductor Types, Thermal Radiation, Quartz Crystal, NQR, Spectroscopic Noise Thermometry, Heat flux sensors.

Radiation Sensors: Basic Characteristics, Photo-emissive Cell and Photomultiplier, Photoconductive Cell - Photovoltaic and Photojunction Cell, Position-Sensitive Cell, X-ray and Nuclear Radiation Sensors. Fibre, PHI Optic Sensors.

Module-4: Electroanalytical Sensors: Introduction, Electro-chemical Cell, Cell potential, Sd. Hydrogen Electrode (SHE), Liquid Junction and Other potentials, Polarization, Reference Electrodes, Sensor Electrodes, Electro-Ceramics in Gas Media.

Module-5: Smart Sensors: Introduction, Primary Sensors Excitation, Amplification, Fitters, Converters, Compensation, Information Coding/Processing, Data Communication and Automation.

Module-6: Digital Transducers: Digital Encoder, Shaft Encoder, Switches: Pressure, Level, Flow, Temperature, Proximity Switches, Limit Switches and its types, Isolators (or Barriers).

Module-7: Recent trends in sensor Technologies: Introduction, Film Sensors, Semiconductor IC Technology, Microelectromechanical System (MEMS), Nano Sensors, Application of Sensors : Automotive Sensors, Home Appliance Sensors, Aerospace Sensors, Sensors for manufacturing, Medical Diagnostic Sensors, Sensors for Environmental Monitoring.

Text Books

1. Sensors and Transducers, 2nd Edition by D. Patranabis

Reference Books

1. Electrical & Electronics Measurements and Instrumentation by A.K.Shawhney, Dhanpat Rai & Sons
2. Electronics instrumentation by H. S. Kalsi [TMH]

Resource Department/Center

1. Electronics and Communication Engineering

Module-1: Blood: Characteristics of blood; Blood cells and their role in immunity; Hemostasis and physiology of blood clotting.

Module-2: 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.

Module-3: 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.

Module-4: 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.

Module-5: Kidney and Urinary system: Anatomy of urinary system and kidney, physiology of water and electrolyte balance, acid-base regulation.

Module-6: Nervous system: 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.

Module-7: Hormones, their control and metabolism; Biological control concept and feedback mechanism.

Text Books

1. Text book of Medical Physiology by Guyton & Hall
2. Anatomy and Physiology by Wilson and Wangh

Advance Signal Processing Techniques in Medicine (3-0-0)

(TMI 1003)

Module-1: Classification of signal and system, Sampling and quantization of Continuous Amplitude Signals

Module-2: Frequency domain representation of biosignals: Z-transform, Difference equation, DFT, FFT.

Module-3: Digital filter Design: FIR and IIR Filter, bilinear transform and impulse invariant techniques, Frequency windowing technique, Equi ripple Chebyshev and Butterworth criterion.

Module-4: Parametric and Non-Parametric Power spectrum estimation

Module-5: Adaptive filtering and Data Reduction Techniques

Module-6: Short term Fourier transform and Wavelet transform

Module-7: Special Techniques for Cardiological and Neurological Signal Processing

Text Books

1. Biomedical Signal Processing Principles and Techniques by D. C. Reddy.
2. Signal Processing of Random Physiological Signals by Charles Lessard, Morgan & Claypool Publishers
3. Biomedical Digital Signal Processing by Willis J. Tompkins.

Reference Books

1. Digital signal processing: principles, algorithms and applications by J. G. Prokias and D. G. Manolakis, Pearson

Resource Department/Center

1. Electrical and Electronics Engineering

Elective-1

Health Informatics and Telemedicine

(3-0-0)

(TMI 1005)

Module-1: Medical data and records, coding, classification, database and reference models, data modeling, data control; Interfaces, data acquisition, processing and exchange standards

Module-2: Patient centered information system; Clinical departmental systems; Clinical support system; Hospital and nursing information system; Implementations and evaluations.

Module-3: Methods of decision support; Clinical decision support system; Medical knowledge acquisition; tools for clinical decision support.

Module-4: Information technology in healthcare: Overview of telemedicine with its origin and development; Drivers of telemedicine and telecare; Types of telemedicine, benefits and limitations.

Module-5: 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.

Module-6: 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.

Module-7: Ethical and legal aspects: Confidentiality, patient rights and consent, data protection and security, telemedical malpractice, intellectual property rights.

Text Books

1. Handbook of Medical Informatics, J. H. van Bommel 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

Resource Department/Center

1. Biomedical Instrumentation

Biomaterials and Artificial Organs**(3-0-0)****(TMI 1007)**

Module-1: Introduction to biomaterials, uses of biomaterials, biomaterials in organs & body systems, materials for use in the body, performance of biomaterials

Module-2: Metallic, Ceramic, Polymeric and Composite Biomaterials : types of metallic biomaterials, dental metals, corrosion of metallic implants, manufacturing of implants; Types of bioceramics, deterioration of bioceramics, bioceramics manufacturing techniques; Polymers used as biomaterials, surface modifications for improving biocompatibility; Types of composite biomaterials.

Module-3: Biodegradable Polymeric Biomaterials: Introduction, Glycolide based biodegradable homopolymers polyesters, non-glycolide linear aliphatic polyesters, aliphatic and aromatic polycarbonates, biodegradation properties of synthetic biodegradable polymers,

Module-4: Tissue Derived Biomaterials: Structure and properties of collagen and collagen-rich tissues, design of resorbable collagen-based medical implant, tissue engineering for tissue and organ regeneration, bone repair and joint implants-long bone repair and joint replacements, dental implants- effects of material selection, effects of surface properties, surface chemistry.

Module-5: Cardiovascular Assist Devices: Artificial Heart, different types of artificial implants, cardiac valve prosthesis, artificial blood.

Module-6: Artificial Organs for Vital System: Artificial liver, artificial pancreas, artificial lungs, artificial kidney

Module-7: Artificial Skin: Vital functions of skin, current treatment of massive skin loss, design principles for permanent skin replacement.

Text Books

1. Biomaterials: An Introduction, J. B. Park, Plenum Press
2. Biomaterials: An Interfacial Approach, L. L. Hench & E. C. Ethridge

Reference Books

1. Biomedical Engineering Handbook Volume1 (2nd Edition), J.D.Bronzino (CRC Press / IEEE Press, 2000).
2. Biomedical Engineering Handbook Volume 2 (2nd Edition), J.D.Bronzino (CRC Press / IEEE Press, 2000)

Resource Department/Center

1. Biomedical Instrumentation
2. Applied Chemistry

Introduction to Nano Science and Nano Technology (3-0-0)

(TNT 1001)

Module-1: Introduction to Quantum Mechanics; Schrodinger equation and expectation values, Solutions of the Schrodinger equation for free particle, particle in a box, particle in a finite well, Reflection and transmission by a potential step and by a rectangular barrier.

Module-2: Angular momentum and its operators, Eigen values and Eigen functions of the angular momentum operators, spin, Pauli spin operators and their properties, hydrogen atom, density of states, free electron theory of metals.

Module-3: Confinement and Transport in nanostructure, Current, Reservoirs and Electron channels, Conductance formula for nanostructures, Quantized conductance. Local density of states. Ballistic transport, Coulomb blockade, Diffusive transport, Fock space.

Module-4: Statistical Mechanics, Microstates and entropy and its statistical definition, Entropy of mixing, Gibb's free energy, Gibb's paradox, phase space density, ergodic hypothesis, Liouville's theorem, The microcanonical-, canonical- and grand canonical- ensemble and their connections, Fluctuations, Classical Statistical systems, Boltzman statistics, and quantum statistical systems, Fermi-Dirac and Bose-Einstein Statistics and their applications.

Module-5: Electronic Properties: Free electron theory of metals, Band theory of solids, Bloch theorem, Kroning-Penne model, Metals and Insulators, Semiconductors: Classification, Transport properties, Size and Dimensionality effects, Band structures, Brillouin zones, Mobility, Resistivity, Relaxation time, Recombination centers, Hall effects.

Module-6: Optical Properties, Photoconductivity, Optical absorption & transmission, Photoluminescence, Fluorescence, Phosphorescence, Electroluminescence.

Module-7: Magnetic Materials: Basic Magnetic Phenomena; Diamagnetism, Paramagnetism, Ferromagnetism, Ferrimagnetism, Anti-ferromagnetism, Some examples of these materials and their applications, RKKY Interactions, Ferrofluids, Introduction to superconductivity; London Equation and Josephson effect.

Text Books

1. T. Pradeep, Nano-The Essentials, McGraw-Hill Publishers, 2008
2. Quantum Physics – A. Ghatak
3. Quantum Mechanics - Bransden and Joachen
4. Statistical Physics by K. Huang
5. Statistical Mechanics-Landau & Lifshitz
6. Quantum wells, Wires & Dots: Theoretical & Computational Physics of Semiconductors Nanosturctures, Paul Harrison
7. Principles of Quantum Mechanics 2nd ed. - R. Shankar
8. Thermodynamics and Statistical Mechanics - A N Tikhonov, Peter T Landberg, Peter Theodore Landsberg
9. Thermodynamics and Statistical Mechanics by John M. Seddon , J. D. Gale
10. Statistical Mechanics – Sonntag
11. Statistical Mechanics – Mc Le Leland

Resource Department/Center

1. Applied Physics

Module-1: Analytical Application of Absorption Spectra: Absorptiometric assay of Organic Compounds, Structural Analysis.

Module-2: Infrared Spectrophotometry: Qualitative uses; Interpretation of I.R. Spectra, Quantitative analysis.

Module-3: NMR-Spectroscopy: The NMR-Signal, Instrumentation practical consideration, chemical shift, spin-spin coupling, Structure elucidation, investigation of dynamic properties of molecules, quantitative analysis.

Module-4: Mass Spectrometry: Theory instrumentation, practical consideration, structure elucidation, detection of impurities, quantitative analysis, application to determination of structure, the gas chromatograph mass spectrometer combination.

Module-5: Optical Rotatory Dispersion: Terminology Plain Curves, Rotatory dispersion of ketones, The Axial Haloketone Rule, Octant Rule.

Module-6: Recent trends in chromatography with reference to analysis of drugs and related substances: HPLC, UPLC, HPTLC, GC and hyphenated techniques(LC-MS/ LCMS/ MS).

Module-7: Theory, Instrumentation and Applications: Thermogravimetric Analysis (TGA), Differential thermal analysis (DTA), Differential Scanning Calorimeter (DSC), X ray Diffraction(XRD).

Books:

1. Practical Pharmaceutical Chemistry (part II) by Beckett and Stenlake.
2. Optical Rotatory Dispersion by C. Djerassi (For ORD).
3. Indian Pharmaceutical (Biological & Microbiological Assay).
4. British Pharmaceutical (Biological & Microbiological Assay).
5. UV and Visible Spectroscopy, Chemical Application-C.N. R. Rao.
6. Spectrometric identification of organic compound- Silverstein.
7. Chemical application of IR spectroscopy – C.N.R. Rao.
8. Physical Methods of Organic Chemistry- Weissberger.
9. Interpretation of Mass Spectra of organic compounds-B. Kienicz, C. Djerassi.
10. Application of NMR Spectra to Organic Chemistry-Jackmann.
11. Instrumental Methods of Analysis- Willard.
12. Applications of Absorption spectroscopy of organic compounds – John R. Dyer.
13. Pharmaceutical Experiments on isolated preparations by the staff of the Department of Pharmacology, University of Edinburg.
14. Pharmacological Techniques in Drug evaluation, Vol. 1&2 by Peter E. Siegler, J.H. Meyer.
15. Lewis Pharmacology- James Crossland.
16. Fundamental of Experimental Pharmacology- M.N. Ghosh.
17. Indian Pharmacopoeia.
18. British Pharmacopoeia.
19. United States Pharmacopoeia
20. Assay of Vitamins by Haskmi

Laboratory

Biomedical Equipment Design

(0-0-3)

(TMI 1002)

1. Design of ECG heart rate alarm system
2. Design of ECG heart rate monitor system
3. Design of ECG simulator
4. Design of EMG biofeedback system
5. Design of Nerve Simulator
6. Design of Electronic Stethoscope
7. Design of Pacemaker
8. Design of Digital Flow monitor
9. Design of Digital Pressure Monitor
10. Design of Biotelemetry
11. Design of Respiration Rate monitor
12. Design of Peripheral Pulse Heart rate system
13. Design of Peripheral Pulse Heart rate monitor
14. Design of Temperature control system

Resource Department/Center

1. Biomedical Instrumentation

Biomedical Signal Acquisition and Processing**(0-0-3)****(TMI 1004)**

1. Display of static and moving ECG.
2. Down sampling & up-sampling of ECG signal.
3. Detection of QRS complex and heart rate measurement.
4. Auto-correlation and cross correlation of ECG signals.
5. DCT and IDCT of ECG signal.
6. Computation of Convolution and Correlation Sequences.
7. Signal Averaging to improve the SNR.
8. PSD estimation for ECG, EEG and EMG.
9. Design of 50 Hz notch filter for ECG signal and display PSD.
10. Design of IIR filters for ECG (LPF, HPF, BP).
11. Design of FIR filters for ECG (LPF, HPF, BP).
12. Data Compression Techniques: AZTEC, TP, FAN algorithms.

Resource Department/Center

1. Electrical and Electronics Engineering
2. Biomedical Instrumentation

Compulsory Non-Credit Papers (for non-Engineering Students)

Fundamentals of Electrical and Electronics Engineering (3-0-0)

(TMI 1021)

Module-1: Introduction: Electrical elements and their classification; KCL and KVL equations; Loop current and Node voltage method; D.C. and A.C. Circuits; Phasor diagram.

Circuit Theorems: Superposition theorem; Thevenin's & Norton's theorem; Maximum Power Transfer theorem.

Module-2: Three Phase Circuits: Line and Phase relation for Star and Delta connection; Power relations; Analysis of balanced and unbalanced 3 phase circuits.

Magnetic Circuits: Series-parallel magnetic circuits; Analysis of Linear and Non-linear magnetic circuits; Energy storage; A.C. excitation; Eddy currents and Hysteresis losses.

Module-3: Coupled Circuits (Dot rule); Self and mutual inductances; Coefficient of coupling. Basic Indicating Instruments: Moving coil and moving iron type instruments.

Module-4: Introduction to PN junction diodes, Characteristics of semiconductor diodes, Zener diode, Characteristics and applications in regulators. Half wave and full wave rectifiers, Elementary clipping and clamping circuits.

Module-5: Fundamentals of Transistors: Introduction to transistor circuits for CB, CE, CC configurations. Transistor biasing and bias stability. JFET & MOSFET, characteristics and biasing. Small signal low frequency analysis of CE, CB and CC amplifiers.

Module-6: Logic circuit implementation of Boolean expressions, Adder, Subtractor, Seven-segment Display, Basic concept of TTL & CMOS logic system, Flip-flops.

Module-7: Operational amplifiers and its applications: Characteristics, Parameters, Measurements, Emitter Coupled Differential amplifier, Transfer Characteristics, voltage gain, Input and Output impedance of Inverting and Non-inverting amplifiers using OP-AMP, Linear and Non-linear applications of OP-AMP: voltage follower, phase inverter, Scale changer, Integrator, Differentiator; Active filters of different orders; Signal modulator.

Text Book:

1. Nagrath and Gopal, Basic Electrical Engineering
2. Fitzgerald and Higinbotham, Basic Electrical Engineering
3. Electronics Devices & Circuits, Millman & Halkias, McGraw Hill
4. Integrated Electronics, Millman & Halkias, McGraw Hill
5. Electronics Fundamentals and Applications", D. Chattopadhyay & P. C. Rakshit, New Age International, 5/E

Resource Department/Center

1. Biomedical Instrumentation

2nd Semester
Theory

Embedded System and Application

(3-0-0)

(MEE 2115)

Module-1: Microcontrollers and their architecture: Introduction, general architecture of microcontrollers and microprocessors, types of microcontrollers, embedded processors. Overview of the 8051 family. 8051 architecture- memory organization, registers and I/O ports. Addressing modes , instruction sets, and assembly language programming. Introduction to C programming in 8051, Watchdog timer, Power down mode: idle/sleep mode.

Module-2: Interfacing: Programming timer/counter. Interrupts- handling and programming. Serial communication using 8051-Interfacing with RS232. 8051 interfacing with keyboard, ADC, DAC, and LCD module interface. Application of microcontroller for square wave and rectangular wave generation, frequency counter etc.

Module-3: Microcontroller RISC family-ARM processor fundamentals: Register Organisation, pipeline, core. ARM instruction sets: data processing, branch ,load-store, interrupts & program status register instructions. Exceptions & interrupts: handling & priorities. Development & Debugging tools for microcontroller based system design: software and hardware tools like {cross assembler, compiler, debugger, simulator, in-circuit emulator.

Module-4: Embedded System Peripherals: Timers, Counters, example of reaction timer, UART, PWM generation, Controlling a dc motor using a PWM. General purpose processor, application specific instruction-set processor's (ASIP) and ASIC's, semiconductor IC's programmable logic device, Processor selection for embedded systems, special purpose processor.

Module-5: PIC microcontrollers: introduction, architecture (block diagram explanation only), and pin details of PIC 16F877 . Memory organization, ports and timers in PIC 16F877.

Module-6: DSP based control of stepper motor: Basic operation of stepper motors, excitation tables of stepper motor, drive system of stepper motor, implementation of control logic using LF 2407 DSP, programming techniques for speed control of stepper motor.

Module-7: DSP Based Control of BLDC Motor: Principle of BLDC motor, torque generation, BLDC motor control system, Implementation of BLDC motor control system using LF2407, subroutine for PWM generation and speed control of BLDC motor.

Text Books

1. Muhammad Ali Mazidi, The 8051 microcontroller and Embedded System, 2006, Pearson Education.
2. PIC 16F877 data book
3. Hamid A. Toliyat, Steven Campbell-DSP-Based Electro-mechanical Motion Control, CRC Press
4. Andrew N Sloss, Dominic Symes, Chris Wright, ARM Developer's Guide, Elsevier

Reference Books

1. ARM processor Data book
2. Kenneth Ayala, The 8051 Microcontroller, 3/ e, Thomson Publishing, New Delhi
3. David Seal, ARM Architecture Reference Manual
4. Wayne Wolf, Computers as Components: Principles of Embedded Computing system design, Else Vier, 2005

Resource Department/Center

1. Electrical and Electronics Engineering

Biomechanics and Human Factors Engineering**(3-0-0)****(TMI 2001)**

Module-1: Fundamentals of Biomechanics: Introduction; Statics; Dynamics; Mechanics of solid: Axial loads, stress, stress-strain diagram, torsion, stress concentration.

Module-2: Musculoskeletal assessment: Fundamentals of musculoskeletal system biomechanics; Gait and motion analysis.

Module-3: Electromyography (EMG) techniques: Signal generation from muscles and its conditioning, single and multichannel EMG; Surface mechanomyography (MMG), techniques and sensors of MMG.

Module-4: EMG in neurophysiological assessments: Compound muscle action potential and motor nerve conduction; Assessments of nerve conduction for neurophysiological analysis; Muscle Cartography; Myoelectric manifestation of muscle fatigue.

Module-5: Biofluid mechanics: Viscosity and viscometry, capillary viscometry, model of peripheral circulation, blood rheology and its application, cell membrane and its characteristics, shear of membrane, synovial fluid.

Module-6: Cardiopulmonary mechanics: General anatomy, electrical conduction system of heart, artificial heart valves, design and characteristics of artificial valves, static lung mechanics, mechanics of breathing, characteristics of respiration, elastic properties of lung, surface tension and surfactant.

Module-7: Human performance engineering: Fundamentals of ergonomics, EMG applications on ergonomics; Human performance engineering, factors affecting human performance, computer based design and analysis tools, model of human system and task interferences.

Text Books

1. Textbook of Biomechanics by S. Pal, Viva Books
2. Electromyography (Physiology, Engineering, and Noninvasive Applications) by Roberto Merletti and Philip Parker (Eds.), IEEE Press, John Wiley & Sons Inc. Publication
3. Orthopedic Rehabilitation, Assessment, and Enablement by David IP, Springer

Reference Book

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

Resource Department/Center

1. Biomedical Instrumentation

Medical Imaging Systems**(3-1-0)****(TMI 2003)**

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, fluorescent screens and Image intensifiers, X-Ray detectors.

Module-2: Applications of X-Ray: X-Ray radiography, Fluoroscopy, Digital radiography, Angiography, Cardiac catheterization lab., Mamography, Dynamic spatial reconstructor, X-Ray image characteristics, darkroom accessories and film processing.

Module-3: Computed Tomography: Conventional tomography, Computed tomography principle, Generations of CT machines, Projection function, Reconstruction algorithms, whole body CT scan, cardiac CT scan.

Module-4: Ultrasound: 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.

Module-5: Radio Nuclide Imaging: Interaction of nuclear particles and matter, Nuclear sources, Radionuclide generators, Nuclear radiation detectors, Rectilinear scanner, scintillation camera, SPECT, PET.

Module-6: 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 magnetic field, Introduction to Functional MRI.

Module-7: Endoscopes: Instrumentation of Endoscope and its attachments, Types of Endoscopes, cold light source, techniques applied in different type of endoscope for imaging.

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

Resource Department/Center

1. Biomedical Instrumentation

Concept of Biomedical Image Processing**(3-0-0)****(TMI 2005)**

Module-1: Fundamentals: Introduction, Fundamental steps in DIP, A simple image formation model, representing digital images, Spatial & Gray level resolution, Basic relationship between pixels.

Module-2: Image Compression, Enhancement and Segmentation: Huffman coding, dft, dct, wavelet coding & jpeg standard. Point operations, spatial averaging, median filtering, spatial low pass, high pass and band pass filtering, histogram equalization, transform operations. Detection of discontinuities, edge linking and boundary detection by local processing & global processing using hough transform, region based segmentation.

Module-3: Image Representation and Description: Representation – chain codes, polygonal approximations, signatures, boundary segments, skeletons, boundary descriptors – some simple descriptors, shape numbers, Fourier descriptors, statistical moments, regional descriptors – some simple descriptors, topological descriptors, texture.

Module-4: Color Image Processing: Color fundamentals, color models, pseudo color image processing, basics of full color image processing, color transformations- formulation, complements, histogram processing, color image smoothing and sharpening, color image segmentation.

Module-5: Morphological Image Processing : basic concepts of set theory, logical operations involving binary images, dilation and erosion, opening and closing, the hit-or-miss transformation, basic morphological algorithms.

Module-6: Motion Analysis: Introduction, optical flow – optical flow computation, global and local optical flow estimation, optical flow computation approaches, optical flow in motion analysis.

Module-7: Biomedical Images: Specialty of biomedical images, 2D and 3D images, static and dynamic images, Application of imaging algorithms in biomedical images.

Text Books

1. Digital Image Processing by Rafael C. Gonzalez & Richard E. Woods, Second_Edition. Pearson Education Inc
2. Fundamentals of Digital Image Processing by Anil K. Jain. Prentice Hall of India
3. Image Processing, Analysis and Machine Vision by Milan Sonka, Vaclav Hlavac & Roger Boyle, 2nd Edition

Reference Books

1. Practical Algorithms for Image Analysis: Description, Examples & Codes by Michael Seul, Lawrence O’Gorman, Michel J.Sammon, Cambridge University Press
2. Biomedical Imaging visualization and analysis by Richard A Robb, John wiley & sons, Inc. publication

Resource Department/Center

1. Electrical and Electronics Engineering
2. Electronics and Communication Engineering

Elective-2

Physiological Control Systems

(3-0-0)

(TMI 2007)

Module-1: Introduction: Systems Analysis, Physiological Control Systems Analysis, Differences between Engineering and Physiological Control Systems, The Science (and Art) of Modeling

Module-2: Mathematical Modeling: Generalized System Properties, Models with Combinations of System Elements, Linear Models of Physiological Systems, Distributed-Parameter versus Lumped-Parameter Models, Linear Systems and the Superposition Principle, Laplace Transforms and Transfer Functions, The Impulse Response and Linear Convolution, State-Space Analysis, Computer Analysis and Simulation

Module-3: Static Analysis of Physiological Systems: Open-Loop versus Closed-Loop Systems, Determination of the Steady-State Operating Point, closed and open loop Regulation of Cardiac Output, Regulation of Glucose, Chemical Regulation of Ventilation, The Gas Exchanger, The Respiratory Controller, Closed-Loop Analysis: Lungs and Controller Combined.

Module-4: Time-Domain Analysis of Linear Control Systems: Linearized Respiratory Mechanics: Open-Loop versus Closed-Loop, Open-Loop and Closed-Loop Transient Responses: First and second-Order Model, Impulse Response, Step Response, Open-Loop versus Closed-Loop Transient Responses, Reduction of the Effects of External Disturbances, Reduction of the Effects of Parameter Variations, Integral Control, Derivative Feedback, Transient Response Analysis

Module-5: Frequency-Domain Analysis of Linear Control Systems: Steady-State Responses to Sinusoidal Inputs, Open-Loop Frequency Response, Closed-Loop Frequency Response, Relationship between Transient and Frequency Responses, Graphical Representations of Frequency Response, Bode Plot Representation, Nichols Charts, Nyquist Plots, Frequency-Domain Analysis, Frequency Response of a Model of Circulatory control, frequency Response of the Model, Frequency Response of Glucose-Insulin Regulation.

Module-6: Stability Analysis: Linear Approaches: Stability and Transient Response Root Locus Plots Routh-Hurwitz Stability Criterion Nyquist Criterion for Stability Relative Stability Stability Analysis of the Pupillary Light Reflex Routh-Hurwitz Analysis Nyquist Analysis Model of Cheyne-Stokes Breathing CO₂ Exchange in the Lungs Transport Delays Contents Controller Responses Loop Transfer Functions

Module-7: Nonlinear Analysis of Physiological Control Systems Nonlinear versus Linear Closed-Loop Systems Phase-Plane Analysis Local Stability: Singular Points Method of Isoclines Nonlinear Oscillators Limit Cycles The van der Pol Oscillator Modeling Cardiac Dysrhythmias The Describing Function Method Methodology Application: Periodic Breathing with Apnea Models of Neuronal Dynamics Hodgkin-Huxley Model The Bonhoeffer-van der Pol Model

Text Books

1. Physiological Control Systems by M. C. K. Khoo, PHI, 2001
2. Modern Control Theory by M. Gopal

Resource Department/Center

1. Biomedical Instrumentation

Rehabilitation Engineering**(3-0-0)****(TMI 2009)**

Module-1: Fundamentals of rehabilitation engineering: Introduction, rehabilitation science, technology and engineering, rehabilitation engineering in sensory, motor and communication system; measurement tool and process in rehabilitation engineering.

Module-2: Orthopedic prosthetic and orthotics in rehabilitation; externally powered and controlled orthotics and prosthetics.

Module-3: Introduction to Sensory-Motor augmentation; Stroke and Stroke Rehabilitation; Approaches in Human-Computer Interfaces.

Module-4: Rehabilitation of Speech, Language and Swallowing Disorders; Techniques in tactile rehabilitation.

Module-5: Assistive technology in hearing: Pure tone audiometry, immittance audiometry; Electric response audiometry; audiometric equipment design and calibration; Different types of electronic hearing aids.

Module-6: Assistive technology in vision: Visual activity measurement, field of vision test, pressure measurement, biometry, optical coherence tomography; ocular electrophysiology; Haptics as a substitute of vision; Mobility aids for visually impaired.

Module-7: Challenges in designing a rehabilitation system; Behavioral and learning problems in disabled; Sociolegal aspects of Rehabilitation.

Text Books

1. Assistive Technology for Visually Impaired and Blind People by Marion A. Hersh and Michael A. Johnson (Eds.), Springer
2. Assistive Technology for the Hearing-impaired, Deaf and Deafblind by Marion A. Hersh, Michael A. Johnson (Eds.), Springer
3. Textbook of Rehabilitation by S. Sunder, Jaypee Medical Publications, New Delhi.
4. Acquired Brain Injury-An Integrative Neuro-Rehabilitation Approach, Jean Elbaum Deborah M. Benson (Eds.), Springer.

Reference Book

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

Resource Department/Center

1. Biomedical Instrumentation

Module-1: Introduction

- (A) A Basic Principles, Modelling Natural Systems, Differential Equations, Dynamic Systems Theory, Dealing with uncertainty, The System Biology approach, Cell Chemistry, Model behavior, Typical aspects of Biological Systems and corresponding models.
- (B) Biology in Nutshell: The origin of life, Molecular Biology of the cell, Major classes of Biological Molecules, Structural Cell Biology, Expression of Genes, Cell cycle.

Module-2: Biochemical Reactions

- (A) Enzyme kinetics and Thermodynamics, The ODE Approach, Biochemical reaction modeling, Fundamental quantities and definitions, Basic principles and assumptions, Elementary reactions, Complex reactions, Parallel reactions, Autocatalytic reactions.
- (B) Mathematical representation of Reconstructed Networks: Basic features of Stoichiometric Matrix, Topological properties, Fundamental subspaces of S, The (Right) Null Space of S, The left Null space of S, row and column spaces of S.

Module-3: Dynamic systems Approach

- (A) Pathways as Dynamic Systems, The Role of Feedback, Phase-plane Analysis Nonlinear Dynamics.

Module-4: Stochastic Modelling and Simulation

Introduction, Mass action models the average of CME? Stochastic Simulation, AN ODE to Differential Equations, Steady State Solution for the master equation, Temporal evolution of average and variance, Generating functions, summary.

Module-5: Dynamic Modelling of Biochemical Networks

Michaelis-Menten modelling, Multinomial Systems, S-System, The Heinrich model MAP Kinase (MAPK) Pathway, The Ras/Raf/MEK/ERK Pathway, Feedback and Oscillations in Signaling pathways.

Module-6: Modules and Control Mechanisms

Linear Module, Hyperbolic Model, Sigmoid Module, Robust or Adaptive Module, Feedback Systems.

Module-7: Modelling of Gene Expression

Modules of Gen Expression, Promoter identification, Modelling specific Processes in Eukaryotic Gen Expression. Modelling the expression of operons in E.Coli.

Text Books

1. Systems Biology Dynamic Pathway Modeling – Olaf Wolkenhauer
2. System Biology Practice, Concepts, Implementation and Application by E. Klipp, R. Herwig, A. Konold, C. Wierling, H. Lehrach
3. Systems Biology Properties of Reconstructed Networks – Bernhard O. Palsson

Resource Department/Center

1. Electrical and Electronics Engineering

Artificial Intelligence Applications in Biomedicine (3-0-0)

(TMI 2011)

Module-1: Learning and Soft Computing: Examples, basic tools of soft computing, basic mathematics of soft computing, learning and statistical approaches to regression and classification.

Module-2: Single Layer and Multilayer Networks: Perception, adaptive linear neuron (Adaline) and the LMS algorithm. Error back propagation algorithm, generalized delta rule, practical aspects of error back propagation algorithm.

Module-3: Unsupervised neural networks

Module-4: Radial Basis Function Networks: ill posed problems and regularization technique, stabilizers and basis functions, generalized radial basis function networks.

Module-5: Fuzzy Logic Systems: Basics of fuzzy logic theory, mathematical similarities between neural networks and fuzzy logic models, fuzzy additive models.

Module-6: Support Vector Machines: Risk minimization principles and the concept of uniform convergence, VC dimension, structural risk minimization, support vector machine algorithms.

Module-7: Genetic Algorithms: Fundamentals, probabilistic system, application of genetic algorithms in medicine.

Text Books

1. Neural networks and artificial intelligence for biomedical engineering by D. L. Hudson and M. E. Cohen, Prentice Hall of India
2. George J. Klir and Bo yaun, "Fuzzy sets and Fuzzy Logic: Theory and Application", Prentice Hall of India, 2001
3. S. Haykin, "Neural networks: A Comprehensive Foundation" Pearson Education (Asia) Pte. Ltd/Prentice Hall of India, 2003

Resource Department/Center

1. Electrical and Electronics Engineering

Laboratory

Biomedical Image Processing

(0-0-3)

(TMI 2004)

1. Display (reading) of an image.
2. Image Enhancement.
3. Image Compression.
4. Image Segmentation.
5. Image Representation & Description.
6. Color Image Processing.
7. Morphological Image Processing.
8. Motion Analysis.

Using MATLAB or C Language

Resource Department/Center

1. Electrical and Electronics Engineering

Embedded System Application Lab.

(0-0-3)

(MEE 2116)

Resource Department/Center

1. Electrical and Electronics Engineering



**DEPARTMENT OF BIOTECHNOLOGY
BIRLA INSTITUTE OF TECHNOLOGY**

(A Deemed University u/s 3 of UGC Act, 1956)

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Ref: BT/BOS /01/10-11

Date: 22.07.2010

Minutes of Board of Studies Meeting

A meeting of Board of Studies of the Department of Biotechnology was held on 22.07.2010 to modify the existing courses of M.Sc. Bioinformatics programme. Following members were present and approved the course structure and the syllabus.

Dr. K. Mukhopadhyay
Member

Dr. A. Sachan
Member

Dr. (Mrs.) Usha Jha
Member

Dr. A. S. Vidyarthi
Head & Chairman

* Dr. S. P. Bhatnagar and Dr. R. T. Goswami, Member of the Board of Studies could not attend the meeting.

2020/6/22 15:46

DEPARTMENT OF BIO-ENGINEERING
BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
M Sc (Bioinformatics)
Course Structure

Semester 1

Sl. No.	Subject code	Offering Department	Name of the Subject	L (h/week)	T (h/week)	P (h/week)	Credits
1	SBI 1001	BT	Bioinformatics Fundamentals	3	0	0	3
2	SBI 1003	BT	Biological Chemistry	3	0	0	3
3	IMCA 1005	IT	Problem Solving & Program Design in C (BR1)	3	0	0	3
4	SAM 1007	AM	Biomathematics I: Basic Calculus	3	1	0	4
5	TCS 1021	CS	Data Structure and Algorithm design	3	0	0	3
6	SBI 1002	BT	Bioinformatics Lab I	0	0	6	2
7	SCS 1052	CS	C Programming Lab	0	0	6	2
S	Total Credits						20

Semester 2

Sl. No.	Subject code	Offering Department	Name of the Subject	L (h/week)	T (h/week)	P (h/week)	Credits
1	SBI 2001	BT	Cell Biology and Molecular Genetics	3	0	0	3
2	SBI 2003	BT	Structural Biology	3	0	0	3
3	SAM 2007	AM	Biomathematics II: Mathematics in Biology	3	1	0	4
4	SAM 2009	AM	Biostatistics (BR2)	3	0	0	3
5	MCA 2005	CS	Database Management System	3	0	0	3
6	SBI 2002	BT	Cell and Molecular Biology Lab	0	0	6	2
7	SBI	BT	Bioinformatics Lab II	0	0	6	2

	2004						
	Total Credits						20

Semester 3

Sl. No.	Subject code	Offering Department	Name of the Subject	L (h/week)	T (h/week)	P (h/week)	Credits
1	SBI 3001	BT	Genomics and Bio-sequence Analysis	3	0	0	3
2	SBI 3003	BT	Molecular Modeling and Drug Design	3	0	0	3
3	SBI 3005	BT	Perl Programming & Web Technology	3	1	0	4
4	MCA 5001	CS	Computer Graphics	3	0	0	3
5		Other	Elective*	3	0	0	3
6	SBI 3004	BT	Bioinformatics Lab III	0	0	6	2
7	MCA 5002	BT	Computer Graphics Lab	0	0	6	2
	Total Credits						20

Semester 4

		L (h/week)	T (h/week)	P (h/week)	Credits
SBI 4001	PROJECT WORK			40	16
SBI 4002	Colloquium and Term Paper			3	04
Total Credit					20

Total Credit in all Semesters

$$20+20+20+20 = 80$$

L= Lecture; T= Tutorial; P= Practical

List of Electives:

Elective	SBI 3011	Genetic Engineering
	SBI 3017	Nano Biotechnology
	SBI 3019	Biological Engineering
	SBI 3021	Cheminformatics
	SBI 3023	Metabolic Pathways

Semester – I

SBI 1001 BIOINFORMATICS FUNDAMENTALS

Module 1: Major Information Resources & Databases in Bioinformatics

Information Resources: NCBI, EBI, ExPasy, Entrez & SRS System, Derived (Secondary) Databases of Sequences, Different Biosequence File Formats.

Module 2: Sequence Alignment Basics:

Similarity, Identity, Homology, Selectivity/Sensitivity, Linear and Affine Gap Penalty, Basics of Scoring system and matrices (PAM, BLOSUM, GONNET etc).

Module 3: Sequence Alignment Methods:

Brute Force method, Dot matrix method, Global (Needleman-Wunsch) and Local Alignment (Smith-Waterman) using Dynamic programming

Module 4: Multiple Sequence Alignment Basics:

Multiple Sequence Alignment: Basic Concepts, Scoring methods of MSA (Sum of Pair, Multidimensional DP, Progressive, Iterative, Probabilistic), CLUSTALW/X tool.

Module 5: Similarity Searching Tools:

BLAST and FASTA, Theory and Algorithms, variants of BLAST and FASTA, PSI-BLAST and PHI BLAST, Statistical Significance.

Module 6: Phylogenetic Analysis:

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

Module 7: Sequence Pattern and Profiles:

Concepts of motif, pattern and profile and its application in Bioinformatics

Textbook

1. **Bioinformatics: Sequence and Genome Analysis**, David W Mount, Cold Spring Harbor Laboratory Press, New York (September 2004)

Reference:

1. **Bioinformatics: a practical guide to the analysis of genes and proteins**, Baxevanis A., Ouellette F.B.F., John Wiley and Sons, New York
2. **Fundamental Concepts of Bioinformatics**, Dan E Krane, Michael L Raymer, Benjamin- Cummings Pub Co (Sept 2002, ISBN 0805346333)

SBI 1003 BIOLOGICAL CHEMISTRY

Module 1: pH and Buffers:

Concept of pH, pK, chemical equilibrium, structure of water, ionization of weak acids, ionization of weak bases, Henderson-Hasselbalch equation, Biological buffer systems.

Module 2: Biomolecules:

Structure and classification of monosaccharides, oligosaccharides and polysaccharides, biological importance, structure, classification and properties of amino acids, peptide bonds, proteins, their physico-chemical properties, Nucleic acid (structure properties and importance.)

Module 3: Enzymes:

Nomenclature and classification, Units of activity, Coenzymes, active sites, effect of temperature and pH on activity, Inhibitors and Activators, Michaelis - Menten kinetics and significance. Isoenzymes

Module 4:

Allosteric enzymes, mechanism of regulation, sequential and concerted model, feedback inhibition, Isoenzymes

Module 5: Bioenergetics:

Laws of thermodynamics, Entropy and the role of free energy, role of ionic balance and membrane potential. Reversible and Irreversible processes.

Module 6: Carbohydrate metabolism:

Introduction, Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis, Pentose phosphate pathway,

Module 7:

TCA cycle, Electron transport chain and Oxidative phosphorylation

Textbook:

1. David L. Nelson, Albert L. Lehninger, Michael M. Cox, *Lehninger Principles of Biochemistry*, 4th Edition. W H Freeman & Co (April 2004)
2. Cohn and Stumpf, *Outlines of Biochemistry*, 4th Edition, John Wiley & sons

Reference:

1. Lubert Stryer, Jeremy Mark Berg, John L. Tymoczko, *Biochemistry*, 5th Edition (Illustrated) by W H Freeman & Co
2. R Murray, D Granner et al. *Harper's Biochemistry* by 25th edition, Me Graw hill.
3. D Voet, *Biochemistry* by 2nd Edition, John Wiley & sons.

IMCA 1005 Problem Solving & Program Design in C (BR1)

SAM 1007 Biomathematics-I: Basic Calculus

Module 1:

Introduction to Set theory, Operations on sets, Logic, Compound Statements, Truth table, Tautology, Method of Induction. Real numbers, Algebraic Properties of Real Numbers, Complex Numbers, DeMoivre's Theorem and Applications. (4L)

Module 2:

2D-Geometry: Distance between two points, Straight line, angle between two straight lines, Circles, Intersection of two Circles. 3D-Geometry: Preliminary Ideas, Planes and Sphere. (5L)

Module 3:

Relations and their Properties, Types of Relations, Functions, Types of Functions, Basic Properties of Functions. (6L)

Module 4:

Limits and Continuity, Notion of Continuity of a Function, Discontinuous Function, Elementary Problems on Limits, Derivative of a Function, Successive Differentiation, Leibnitz Theorem, Rolle's Theorem, Lagrange's and Cauchy's Mean Value Theorem, Taylor's and Maclaurin's Series, Indeterminate Forms, L'Hospital's Rule, Maxima, minima, Concavity, Convexity, Points of Inflexion. (12L)

Module 5:

Functions of Two Variables, Partial Derivatives, Euler's Theorem on Homogeneous Functions, Total Derivatives, Taylor's Series in Two Variables, Lagrange's Method of Undetermined Multipliers, Jacobians. (4L)

Module 6:

Integral Calculus: Concepts of Integration and Basic Formulas, Integration by Substitution and by Parts, Definite Integration, Calculation of Area and Volume. (5L)

Module 7:

Introduction to Ordinary and Partial Differential Equations, Formation of Ordinary and Partial Differential Equations, Solutions of First Order Ordinary Differential Equations. (4L)

Textbooks:

1. Differential Calculus by Das and Mukherjee, U.N.Dhar and Company.
2. Integral Calculus by Das and Mukherjee, U.N.Dhar and Company.
3. Engineering Mathematics by H.K.Dass.
4. Higher Engineering Mathematics by B.S. Grewal, Khanna Publishers.

TCS 1021 DATA STRUCTURE & ALGORITHM DESIGN

Module 1: Introduction to Algorithm:

Analysing algorithms, Designing algorithms, growth of functions, summations recurrences

Module 2: Sorting:

Insertion Sort, Heap Sort, and Quick Sort, Sorting in Linear Time, Medians and order Statistics

Module 3: Data structure

Elementary Data Structure, Hash Tables, Binary Search Tree, and Red-Black Trees, Augmenting Data Structure

Module 4: Design and analysis techniques:

Dynamic programming, Greedy Algorithms, Backtracking, Branch & Bound, and Amortized Analysis.

Module 5: Advanced Data Structure:

B-Tree, Binomial Heap, fibonacci Heaps, Data structure for distinct sets.

Module 6: Graph Algorithms:

Minimum spanning trees, single source shortest path, All paths shortest paths. Maximum flow

Module 7: Comparison networks:

zero one principle, a bitonic sorting network, strasson's Algorithm for matrix multiplication, Efficient FFT implementation, string matching, NP-completeness, Approximation Algorithms.

Text Book:

Introduction to Algorithms by T.H. Cormen, C.E. Leiserson, R.L Rivest, PHI

Reference Books:

1. Introduction to Design and Analysis of algorithm by S.E. Goodman, S.T. Hedetniemi
2. Data structure and algorithms by G.A.V. PAI.
3. Algorithm design by J.Kleinberg, E. Tardos Pearson education.

SBI 1002 BIOINFORMATICS LAB I

1. Linux and Unix OS: Overview, Installation and System handling commands
2. Working with Internet: WWW, TELNET, FTP
3. Accessing Online Bioinformatics Resources, Database Searching Techniques: NCBI, EBI, DDBJ.
4. Pairwise sequence Alignment: BLAST and FASTA, Multiple Sequence alignments: Clustal W/X and web based programs
5. Phylogenetic analysis using Phylip (various analysis and drawing rooted and unrooted trees)

SCS 1052 C PROGRAMMING LAB

1. C Programming : Windows and Linux platform

Semester – II

SBI 2001 CELL BIOLOGY AND MOLECULAR GENETICS

Module 1: Cell Basics:

Structure of Prokaryotic and Eukaryotic cells, membranes and cellular compartments, Structure and function of cell organelles – plasma membrane, cell wall, their structural organization; mitochondria, chloroplast, nucleus, and other organelles and their organization.

Module 2: Cell Motility:

Self assembly and structure of cytoskeleton filaments, how cells regulate cytoskeleton filaments, molecular motors, cilia, and flagella of prokaryotes and eukaryotes

Module 3: Cell-cell interactions:

General principles of cell communication, signal transduction pathways, signaling through G-protein linked cell surface receptors, signaling through enzyme linked cell surface receptors, signaling pathways that depend on regulated proteolysis.

Module 4: Cell cycle and its regulation:

Overview of the cell cycle control system, components of the cell cycle, cell cycle progression, intracellular control of the cell cycle events, extracellular control of cell division, cell growth, and apoptosis.

Module 5: Molecular biology Basics:

DNA structure, DNA replication in prokaryotes and eukaryotes, mechanics of DNA replication, enzymes, and accessory proteins involved in DNA replication.

Module 6: Central dogma of molecular biology:

RNA transcription, transcription factors, regulatory elements, transcription regulations. Translation machinery, mechanisms of initiation, elongation, and termination, regulation of translation, co- and post translation modifications of proteins

Module 7: Principles of genetics:

Inheritance, linkage and crossing over. Genes-definition, structure of eukaryotic and prokaryotic genes. The genetic code, gene expression and regulation in prokaryotes and eukaryotes. Mutations and mutagenesis-UV and chemical mutagens, types of mutations, mapping mutations at molecular level.

Textbook:

1. Molecular biology of the gene by Watson et. Al (5th edition) ISBN: 8177581813
2. Molecular biology of the cell by Bruce Albert et al (4th edition) ISBN: 815332181

Reference:

1. **Genes VII** by Benjamin Lewin, Oxford University Press ISBN: 019879276X
2. **Molecular Cell Biology**, by Harvey Lodish, Matthew P. Scott, P Matsudaira, J Darnell, L Zipursky, Chris A. Kaiser, A Berk, M Krieger, publisher: W. H. Freeman; 5th edition, ISBN: 0716743663

SBI 2003 STRUCTURAL BIOLOGY**Module 1:**

Structure, function and physico-chemical properties of Nucleic Acid and Proteins. Level of protein structures: Primary, Secondary, Super-secondary, Tertiary and quaternary structures.

Module 2:

Protein-Protein Interaction, Protein-Nucleic acid interaction and Protein- carbohydrate interaction.

Module 3:

Methods of Structure Determination: X-Ray and NMR

Module 4:

Structure alignment: superimposition and RMSD calculations, various methods such as DALI, VAST etc

Module 5:

Classification of 3-D structures of proteins, SCOP, CATH, Motif, Domains, Fold and Fold Libraries

Module 6:

3-D Structure Prediction, RNA Structure prediction, Protein Structure Prediction methods

Chou-Fasman, Garnier-Osguthorpe-Robson, Neural Network

Module 7:

Comparative Modelling of Proteins, Fold recognition method (Threading), Ab-initio predictions

Textbook:

1. **Introduction to Protein Science** by Arthur Lesk, Oxford university press

Reference:

1. Michael J. E. Sternberg *Protein Structure Prediction - A Practical Approach*, ISBN: 0-19-963496-3
2. Philip E. Bourne, Helge Weissig, *Structural Bioinformatics*, , John Wiley, ISBN: 0-471-202002

SAM 2007 Biomathematics-II: Mathematics in Biology

Module 1:

Population models for a single species (discrete and continuous time models), Malthusian Models of resource limitations, Constant and random environment, simple spatial models, Discrete time population models, Logistic Map (10L)

Module 2:

Demography. Simple Age- and Size-Structured Populations, The Euler-Lotka demographic equation, Applications to the Theory of Life-History strategies.(5L)

Module 3:

Microbiological models: biodegradation and Chemostat Theory. (3L)

Module 4 & 5:

Enzyme Kinetics, Multi-species Communities: Competition Models, Coexistence, Predator-Prey Models, Optimal Foraging, Host-Parasite Models and their Dynamics, Models of Disease Transmission (epidemics). (12L)

Module 6:

Many Species Interactions, General Lotka-Volterra models, Applications of Lyapunov functions. (5L)

Module 7:

Spatially-Distributed models: Conservation equation, Random walk and diffusion, Fick's Laws, Diffusion in Biological Settings. (5L)

Textbooks:

1. Elements of Mathematical Biology by Mark Kot (CUP,2001).
2. Evolutionary Games and population dynamics by Joseph Hofbauer and Karl Sigmund (CUP,2002).
3. Mathematical Biology-I & II, J.D. Murray (Springer-Verlag Texts, 1989.)
4. A Primer in Ecology by N.J. Gotelli (Sinaur Associates Inc.).

SAM 2009 BIOSTATISTICS

Module 1:

Frequency distribution, Measures of central tendency-Mean, Median, Mode (3L)

Module 2:

Measures of dispersion-Mean deviations, standard deviations, coefficient of variation (2L), Correlation and regression-correlation coefficient, linear regression (3L)

Module 3: Probability Theory (8L)

Classical Definition, Independent events, conditional probability, theorems of compound and conditional probability (without proof), Bayes' theorem, Simple Problems

Module 4: Probability Distribution (8L)

Discrete, continuous - Binomial, Poisson, Normal

Module 5: Sampling Theory (6L)

Advantages, Simple random sampling – with and without replacement, Sampling distribution of sample mean and sample proportion, Estimator – Point (unbiased) and Interval

Module 6: Test of Hypothesis (10L)

Type-I and Type-II error, one-tailed and two-tailed test, Testing for a specific mean and Equality of two means, testing for a specific proportion of defectives and equality of two Proportions of defectives, Non-parametric tests (Chi square tests for goodness of fit and Independence of attributes)

Module 7: Analysis of Variance (4L)

One-way and two-way classified data

Textbook:

1. Erwin Kreyszig, Engineering Mathematics
2. Gupta and Gupta, Business Statistics, S. Chand and Company

MCA 2005 DATABASE MANAGEMENT SYSTEM

MODULE - I

Introduction: Purpose of Database Systems, Data Models, Schemas and Instances, Three-Schema Architecture and Data Independence, Database languages, Database Architecture, Classification of DBMS, relational database, Database users and Administrators, Advantages of DBMS.

MODULE - II

E-R-Model: Entities and Entity Sets, Relationships and Relationship Sets, Keys, Mapping, Constraints, ER Diagram, Reducing ER Diagram to tables, Generalization and Specialization, Aggregation.

MODULE - III

Relational Model: Concepts, Constraints and Relational database Schemas, Relational Algebra, Relational Calculus, QUEL, QBE, SQL..

MODULE - IV

Database Design: Pitfalls in relational database design, Normalization using functional, Multivalued and join dependencies, DKNF, Atomic values, alternative approaches to database design.

MODULE - V

Security & Integrity: Security & Integrity violations, authorization and views, integrity constants, encryption, Statistical databases.

MODULE - VI

Transaction Processing and Concurrency Control: Transaction Processing, Schedules and Recovery, Locking and Timestamp Ordering for concurrency control.

MODULE - VII

Distributed Databases: Concepts and Types of Distributed databases, data fragmentation, Replication and Allocation

Text Book:

1. Fundamentals of Database Systems "Ramez Elmasri", Pearson Education

Reference Book:

1. Database Systems Concepts "A. Silberschatz,Korth", McGraw Hill.

SBI 2002 CELL AND MOLECULAR BIOLOGY LAB

1. Molecular Biology Lab: Overview and safety measures, Microbial cultures: Media preparation, Streaking, Plating.
2. DNA isolation, Gel-Electrophoresis, PCR for DNA amplification, Genome sequencing: method and strategies.
3. Proteome analysis by ID method and Data Analysis.

SBI 2004 BIOINFORMATICS LAB II

1. Accessing Structural Biology Databases: CATH, SCOP, DALI, VAST,
2. Biological Sequence Analysis
3. Biology Workbench (Online)
4. EMBOSS (Online and Local)
5. *In Silico* Gene Prediction Tools: Online and local tools, GLIMMER & HMMER
6. Protein Structure Prediction Tools : Online, Expasy

Semester – III

SBI 3001 GENOMICS AND BIOSEQUENCE ANALYSIS

Module 1:

Structure, function and physico-chemical properties of Nucleic Acid, DNA sequencing techniques, Next generation sequencing techniques, Genome sequencing strategies, Genome assembly, Gene identification methods, Genome annotation techniques, Comparative genomics.

Module 2:

Microarray - the technique, Experimental design & Data analysis, Application of Microarray, Proteins Arrays and Protein Chips, Single nucleotide polymorphisms, Genomics in drug discovery

Module 3:

Proteomics Basics, Proteomics Tools and Databases, Protein Identification and Analysis, Protein Identification by mass spectrometry, Identification of post translation modification

Module 4:

Suffix tree and its applications in Bioinformatics

Module 5:

Statistical modeling: Log-likelihood, Maximum-likelihood and Expectation Maximization, Bayesian network, Markov and hidden markov models.

Module 6:

Clustering Algorithms, K-means, Fuzzy C-means, Hierarchical and Mixture of Gaussian

Module 7:

Machine learning: Artificial-Neural Network, Support vector machine, Genetic Algorithms, Decision trees, Self Organizing maps, K-nearest neighbor

Textbook:

1. *Biological sequence analysis. Probabilistic models of proteins and nucleic acids.* Durbin R., Eddy S.R., Krogh A., Mitchison G., Cambridge University Press, Cambridge (1998).
2. *Machine Learning*, Tom Mitchell, McGraw Hill, 1997.

Reference:

1. Neil C. Jones, Pavel A. Pevzner, *An Introduction to Bioinformatics Algorithms* (Computational Molecular Biology), Bradford Books / August 2004 / 0262101068
2. Gregory R. Grant, Warren J. Ewens, *Statistical Methods in Bioinformatics: An Introduction*
3. B. Kosko, *Neural Network & Fuzzy systems*, PHI publisher

4. T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*.
5. Richard Duda, Peter Hart, & David Stork, *Pattern Classification* (2nd edition)

SBI 3003 MOLECULAR MODELLING AND DRUG DESIGN

Module 1:

Basics of Molecular Modelling and Simulation Studies, Molecular Mechanics: Concepts of Force-field, PE representation, Energy minimization techniques

Module 2:

Simulation techniques: Molecular Dynamics, Monte Carlo Simulations

Module 3:

Techniques for Conformation Search: Simulated annealing

Module 4:

Optimization algorithms: Steepest descents, Conjugate gradient, Simulated Annealing

Module 5:

Molecular Docking: Methods and Scoring Functions

Module 6:

Cheminformatics: Basic Concepts, application in screening, QSAR studies

Module 7:

Rational Drug Designing (CADD)

- a. Computer-aided identification, characterization, and comparative analysis of binding sites in target proteins.
- b. Development of pharmacophores based on ligand and/or receptor structures.
- c. Analysis and prediction of protein-ligand complexes: database searching, docking, and design.
- d. Quantitative assessment of binding interactions: free energy calculations and scoring functions

Textbook:

1. ***Molecular Modelling: Principles and Applications, 2nd Edition (Illustrated)*** by Andrew 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

SBI 3005 PERL PROGRAMMING AND WEB TECHNOLOGY

Perl and Bioperl

Module 1:

Introduction and basic syntax, Data types: Scalar, Array, List, Hash, anonymous data types, references, special variables, common built-in scalar, array and hash functions

Module 2:

Regular Expressions, Basic input/output, File handling and File and directory manipulations, Complex data structures using references

Module 3:

Object oriented perl: Scope of a variable, Subroutines, Modules and packages, Objects ,classes, methods, inheritance, polymorphism

Module 4:

- a. CGI-Programming: Passing parameters and Interaction with web and databases
- b. Use of common CPAN modules
- c. Bioperl Introduction, Objects and Classes, Applications: Sequences, Alignments, BLAST analysis

Web Designing, Data communication and Networking

Module 5:

IIS and Active Server Pages: VBScripts, Web Designing: HTML/ DHTML, JavaScript Language, FrontPage.

Module 6:

ISO-OSI Reference Model, Network Topologies and Protocols, Data communication (ISDN, VPN, DSL, Cable modem), LAN (Star, Ethernet, Bus, EPABX), WAN, MAN

Module 7:

Communication links (Wire Pairs, Coaxial cables, Fibre optics, Microwaves, Satellite, Wireless etc), Network Security (Firewall, Packet filtering etc)

MCA 5001 COMPUTER GRAPHICS

Module -I

Introduction: Image Processing as Picture Analysis, The Advantages of Interactive Graphics, Representative Uses of Computer Graphics, Classification of Applications, Development of Hardware and Software for Computer Graphics, Conceptual Framework for Interactive Graphics.

Basic Raster Graphics Algorithms for Drawing 2D Primitives: Overview, Scan Converting Lines, Scan Converting Circles, Scan Converting Ellipses, Filling Rectangles, Filling Polygons, Filling Ellipse Arcs, Pattern Filling, Thick Primitives, Line Style and Pen Style, Clipping in a Raster World, Clipping Lines, Clipping Circles and Ellipses, Clipping Polygons, Generating Characters, SRGP_copyPixel, Antialiasing.

Module- II & III

Graphics Hardware: Hardcopy Technologies, Display Technologies, Raster-Scan Display Systems, The Video Controller, Random-Scan Display Processor, Input Devices for Operator Interaction, Image Scanners.

Geometrical Transformations: 2D Transformations, Homogeneous Coordinates and Matrix Representation of 2D Transformations, Composition of 2D Transformations, The Window-to-View port Transformation, Efficiency, Matrix Representation of 3D Transformations, Composition of 3D Transformations, Transformations as a Change in Coordinate System.

Viewing in 3D: Projections, Specifying an Arbitrary 3D View, Examples of 3D Viewing, The Mathematics of Planar geometric Projections, Implementing Planar Geometric Projections, Coordinate Systems.

Module -IV

Input Devices, Interaction Techniques, and Interaction Tasks: Interaction Hardware, Basic Interaction Tasks, Composite Interaction Tasks.

Representation Curves and Surfaces : Polygon Meshes, Parametric Cubic Curves, Parametric Bicubic Surfaces, Quadric Surfaces.

Module-V

Achromatic and Colored Light: Achromatic Light, Chromatic Color, Color Models for Raster Graphics, Reproducing Color, Using Color in Computer Graphics.

The Quest for Visual Realism: Why Realism?, Fundamental Difficulties, Rendering Techniques for Line Drawings, Rendering Techniques for Shaded Images, Improved Object Models, Dynamics, Stereosis, Improved Displays, Interacting with Our Other Senses, Aliasing and Antialiasing.

Module -VI

Visible-Surface Determination: Functions of Two Variables, Techniques for Efficient Visible-Surface Algorithms, Algorithms for Visible-Line Determination, The z-Buffer Algorithms, List-Priority Algorithms, Area-Subdivision Algorithms, Algorithms for Octrees, Algorithms for Curved Surfaces, Visible-Surface Ray Tracing.

Illumination and Shading: Illumination Models, Shading Models for Polygons, Surface Detail, Shadows, Transparency, Interobject Reflections, Physically Based Illumination Models, Extended Light Sources, Spectral Sampling.

Module-VII

Advanced Raster Graphics Architecture: Simple Raster-Display System, Display-Processor Systems, Standard Graphics Pipeline, Introduction to Multiprocessing, Pipeline Front-End Architectures, Parallel Front-End Architectures, Multiprocessor Rasterization Architectures.

Advanced Geometric and Raster Algorithms: Clipping, Scan-Converting Primitives, Antialiasing, The Special Problems of Text, Filling Algorithms, Making copyPixel Fast, The Shape Data Structure and Shape Algebra.

Text Book:

1. Foley, Van Dam, Feiner, Hughes- Computer Graphics Principles & Practice, 11th edn., Pearson Education, New Delhi, 2004.

Reference Book:

- 1.D. Hearn & M.P.Baker- Computer Graphics, PHI, New Delhi, 2006

ELECTIVE PAPERS

SBI 3011 GENETIC ENGINEERING

Module 1: Molecular Tools for Genetic Engineering

Restriction and modifying enzymes, Gel electrophoresis, Southern blot, Northern blot, Dot blot, Colony & Plaque blot, Western blot. Labeling Probes.

Module 2: Polymerase Chain Reaction

Thermo-stable DNA Polymerases, PCR technique, Designing primers, Inverse PCR, Nested PCR, Touchdown PCR, Auto-segment extension, RT-PCR, RACE PCR, Real-Time Quantitative PCR, Site directed mutagenesis

Module 3: Development of Recombinant Molecules

Cloning vectors (plasmids, cosmids, fosmids, BAC), Expression vectors (prokaryotic, yeast, mammalian), Shuttle vectors, Transformation, Purification of Recombinant Protein by IMAC method.

Module 4: Libraries

Genomic, cDNA, EST, Reduced representation (Cot-based & Methyl filtered) and Metagenomic; Screening libraries with DNA probes and antisera. DNA Sequencing (Maxim-Gilbert, Sanger, Pyrosequencing, 454), Genome Projects & Strategies for Whole Genome Sequencing.

Module 5: Gene Regulation

Genetic elements that control gene expression in prokaryotes and eukaryotes, Regulation in bacteriophage λ (*lac* operon, *trp* operon), Epigenetics, RNAi (Antisense, MiRNA) Common methods used to study Gene Expression (Northern Microarray, SAGE, RealTime PCR)

Module 6: Applications Of Recombinant DNA Technology

Transgenic plants and animals, DNA vaccines, Edible vaccines, Gene therapy, PCR based diagnosis.

Module 7: Genetic Engineering & Society

Safety guidelines for Genetic Engineering Research, Genetically engineered organisms, genetically modified foods, Ethical issues in recombinant DNA research.

Text & Reference Books:

1. Old and Primorose- Gene Manipulation
2. Alberts et al, Molecular Biology of the Cell
3. Watson, Recombinant DNA.

SBI 3013 IMAGE PROCESSING

Module 1:

History and scope

Module 2:

Different Image formats

Module 3:

Image transformations basics: Hough and Fourier

Module 4: I

Image Processing Techniques: Histogram manipulation, filtering, thresholding, segmentation, shape detection, compression and retrieval

Module 5:

Application in Classification, Feature extraction, Pattern recognition, Projection, Multi-scale signal analysis

Module 6:

Techniques: Principal component analysis, Independent component analysis, Self-organizing maps, Hidden Markov Models, Neural network

Module 7:

Matlab programming

Text & Reference Books:

1 Anil K. Jain, Fundamentals of Digital Image Processing (Prentice Hall Information and System Sciences Series) Prentice Hall India, ISBN: 0133361659

2. Rafael C. Gonzalez, Richard E. Woods & Steven L. Eddins Digital Image Processing Using MATLAB Prentice Hall, ISBN: 0130085197

SBI 3015 MEDICAL INFORMATICS

Module 1:

Basic principles of patient and hospital database management (expertise in computing, communication and content)

Module 2:

Medical Information: Sources and Structure

Module 3:

Design medical database system (coding, classification and reference models)

Module 4:

Clinical Information system: concepts and full text database, Accessing and processing biomedical and clinical information

Module 5:

Historic medical data, Medical decision making based on this data

Module 6:

Medical data standards, Tele-medicine and web based application to retrieve information from medical databases

Module 7:

Case study: distributed databases services and high availability techniques

Text & Reference Books:

1. Edward H. Shortliffe, Leslie E. Perreault, Gio Wiederhold, Lawrence M. Fagan, Lawrence M. Fagan(ed) Medical Informatics : Computer Applications in Health Care and Biomedicine (Health Informatics) Publisher: Springer; 2 edition (April 30, 2003) ISBN: 0387984720
2. Rudi Van De Velde, Patrice Degoulet Clinical Information Systems: A Component-Based Approach(Health Informatics) Publisher: Springer; 1 edition (May 12, 2003) ISBN: 0387955380

SBI 3017 NANO BIOTECHNOLOGY

Module 1:

Introduction to nano world: Nano terminology and definition Classification scheme for nanomaterials: Top-down versus bottom – up manufacturing. Structure and properties of fullerenes, carbon nanotubes, metal and polymer nanoparticles.

Module 2:

Novel Physics and Chemistry of Nanodimension: unique chemical, electronic, magnetic, optical, thermal and mechanical properties.

Module 3:

Synthesis of nano particles and composites: Methods of synthesis of nanoparticles, Processing of nano structural materials, synthesis of nano-composites

Module 4:

Characterization of nano particles and composite by Atomic Force Microscopy, Scanning Tunneling Microscopy, Transmission Electron Microscopy, Scanning Electron Microscopy.

Module 5:

Self-assembly of nano particles and nano structural molecular materials, Principle of molecular self assembly and self organization, surfactant solutions, Polymers, biological system and liquid crystals. Self assembled monolayers, thiol and silane monolayers. Langmuir-Blodgett films, topological substrate patterning, DNA directed self assembly.

Module 6:

Properties and problems of inorganic/organic interfaces, Polymer surfaces and interfaces structure and properties.

Module 7:

Interaction of biological molecules with surfaces: manipulation of biomolecules on surfaces: transduction and control of materials and information through biological interfaces: bilayers, bioelectronic and biosensors.

Text & Reference Books:

1. Charles P. Poole, & Frank J. Owens. Introduction to Nano-technology. John Wiley Inter Science 2003
2. Hari Singh Nalwa. Nanostructured material and Nano-Technology. Academic Press New York 2002
3. E.A. Rietman. Molecular Engineering of Nanosystems. Springer Verlag New York 2001
4. John D. Wright and Nico A.J.M. Sommerdijk. Sol-Gel Materials: Chemistry and Application. Taylor and Francis 2001
5. Timp Gregory, Nano-Technology. Academic Press New York 1999

SBI 3019 BIOLOGICAL ENGINEERING

Module 1:

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 behavior, kinetics of product formation.

Mass balance and yield concepts: Yield and maintenance coefficients, calculation based on elemental balances, degree of reduction, theoretical predictions of yield coefficients.

Module 2:

Enzyme kinetics: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for more complex enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems.

Module 3:

Media and air sterilization: introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters.

Module 4:

Agitation and aeration: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_La), measurement of k_La , power requirement for agitation in gaseous and non gaseous systems.

Module 5:

Scale up, operation and control of bioreactors: Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down,

Module 6:

Bioreactor instrumentation and control. Operating considerations for bioreactors: Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors:

Module 7:

Biomedical Engineering: Introduction, tissue engineering, image processing and analysis, instrumentations and applications.

Text & Reference Books:

1. Atkinson and Mavituna, Biochemical Engineering and Biotechnology Handbook.
2. Glazer and Nikaido, Microbial Biotechnology.
3. Shuler and Kargi Bioprocess Engineering: Basic concepts Prentice Hall PTR

SBI 3021 CHEMINFORMATICS**Module 1:**

Introduction to chemoinformatics and its importance in pharmaceutical Research. Common public domain databases and software tools (both commercial and open source) used in chemoinformatics research

Module 2:

Computer representation and searching of chemical structures: 2D and 3D molecular structures, Graph theoretic representations of molecules and substructure searching, Conformation generation and conformation search methodologies for small Molecules, Distance keys, Concept of 3D pharmacophore and methods for deriving 3D pharmacophores

Module 3:

Physiochemical properties, Pharmacological properties and global properties of small molecules, Lipinski's rule and drug-likeness

Module 4:

Molecular descriptors: Different 2D and 3D descriptors, Concept of chemical similarity and different chemical similarity and distance metrics- using 2D and 3D descriptors Similarity analysis

Module 5:

Statistical methods of data analysis and classification methods, Quantative structure activity Relationship (QSAR): 2D and 3D QSAR, QSPR, COMFA

Module 6:

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

Module 7:

Computational prediction of ADMET properties, Designed and focused libraries, Design of virtual combinatorial libraries

Textbook:

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

SBI 3023 METABOLIC PATHWAYS

Module 1: Basics

anabolism / catabolism, differences between catabolic & anabolic pathways.

Module 2: Carbohydrate Metabolism

Glycolysis, Feeder Pathways for Glycolysis, Anaerobic fermentation, Glycogenlysis, Gluconeogenesis, Regulation of glycolysis. Pentose Phosphate Pathway

Module 3: Citric acid cycle

Oxidation of Pyruvate to Acetyl CoA, Reactions, Energetics and Regulation of the cycle, Anaplerotic reactions.

Module 4: Lipid Metabolism

Oxidation of Saturated and Unsaturated, Even and Odd numbered Fatty Acids, Formation of ketone bodies.

Module 5: Nitrogen Metabolism

Transamination, deamination reactions, transport of ammonia from peripheral tissues to liver by glutamine, excretion of nitrogen (Ammonotelic, Ureotelic, & Uricotelic), Urea cycle, Fates of Amino Acids.

Module 6: Phosphorylation

Oxidative Phosphorylation (Electron-Transfer Reactions in Mitochondria, ATP Synthesis and Regulation) and Photophosphorylation (General Features, Photosystem I and II, Electron Flow, ATP Synthesis)

Module 7: Biosynthesis

Overview of biosynthesis of Carbohydrates, Lipids and Aminoacids.

Text & Reference Books:

1. Albert Lehninger, Principles of Biochemistry
2. Lehninger, Nelson, Cox, Principles of Biochemistry
3. Cohn and Stumpf, Outlines of Biochemistry
4. Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Biochemistry
5. M. Treven, Immobilized Enzymes
6. R.K. Murray, D.K. Granner et al., Harper's Biochemistry
7. Voet & Voet, Biochemistry

SBI 3004 BIOINFORMATICS LAB - III

1. Perl and Bioperl Scripting in Bioinformatics.
2. Molecular Modeling using Modeller (Local)
3. Molecular Simulation using GROMACS.
4. Ligand Designing and Molecular Docking: Autodock
5. QSAR application in Drug Design.
6. Web Page Designing: HTML/ DHTML, JavaScript, Front page.

MCA 5002 COMPUTER GRAPHICS LAB

Exercises based on the MCA 5001 Computer Graphics

Breadth Paper for M. Sc. Courses offered by Dept. of Biotechnology

SBI 3001 GENOMICS AND BIOSEQUENCE ANALYSIS

Module 1:

Structure, function and physico-chemical properties of Nucleic Acid, DNA sequencing techniques, Next generation sequencing techniques, Genome sequencing strategies, Genome assembly, Gene identification methods, Genome annotation techniques, Comparative genomics.

Module 2:

Microarray - the technique, Experimental design & Data analysis, Application of Microarray, Proteins Arrays and Protein Chips, Single nucleotide polymorphisms, Genomics in drug discovery

Module 3:

Proteomics Basics, Proteomics Tools and Databases, Protein Identification and Analysis, Protein Identification by mass spectrometry, Identification of post translation modification

Module 4:

Suffix tree and its applications in Bioinformatics

Module 5:

Statistical modeling: Log-likelihood, Maximum-likelihood and Expectation Maximization, Bayesian network, Markov and hidden markov models.

Module 6:

Clustering Algorithms, K-means, Fuzzy C-means, Hierarchical and Mixture of Gaussian

Module 7:

Machine learning: Artificial-Neural Network, Support vector machine, Genetic Algorithms, Decision trees, Self Organizing maps, K-nearest neighbor

Textbook:

1. *Biological sequence analysis. Probabilistic models of proteins and nucleic acids.* Durbin R., Eddy S.R., Krogh A., Mitchison G., Cambridge University Press, Cambridge (1998).
2. *Machine Learning*, Tom Mitchell, McGraw Hill, 1997.

Reference:

1. Neil C. Jones, Pavel A. Pevzner, *An Introduction to Bioinformatics Algorithms* (Computational Molecular Biology), Bradford Books / August 2004 / 0262101068
2. Gregory R. Grant, Warren J. Ewens, *Statistical Methods in Bioinformatics: An Introduction*
3. B. Kosko, *Neural Network & Fuzzy systems*, PHI publisher
4. T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*.
5. Richard Duda, Peter Hart, & David Stork, *Pattern Classification* (2nd edition)

SBI 1003 BIOLOGICAL CHEMISTRY

Module 1: pH and Buffers:

Concept of pH, pK, chemical equilibrium, structure of water, ionization of weak acids, ionization of weak bases, Henderson-Hasselbalch equation, Biological buffer systems.

Module 2: Biomolecules:

Structure and classification of monosaccharides, oligosaccharides and polysaccharides, biological importance, structure, classification and properties of amino acids, peptide bonds, proteins, their physico-chemical properties, Nucleic acid (structure properties and importance.)

Module 3: Enzymes:

Nomenclature and classification, Units of activity, Coenzymes, active sites, effect of temperature and pH on activity, Inhibitors and Activators, Michaelis - Menten kinetics and significance. Isoenzymes

Module 4:

Allosteric enzymes, mechanism or regulation, sequential and concerted model, feedback inhibition, Isoenzymes

Module 5: Bioenergetics:

Laws of thermodynamics, Entropy and the role of free energy, role of ionic balance and membrane potential. Reversible and Irreversible processes.

Module 6: Carbohydrate metabolism:

Introduction, Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis, Pentose phosphate pathway,

Module 7:

TCA cycle, Electron transport chain and Oxidative phosphorylation

Textbook:

1. David L. Nelson, Albert L. Lehninger, Michael M. Cox, *Lehninger Principles of Biochemistry*, 4th Edition. W H Freeman & Co (April 2004)
2. Cohn and Stumpf, *Outlines of Biochemistry*, 4th Edition, John Wiley & sons

Reference:

1. Lubert Stryer, Jeremy Mark Berg, John L. Tymoczko, *Biochemistry*, 5th Edition (Illustrated) by W H Freeman & Co
2. R Murray, D Granner et al. *Harper's Biochemistry* by 25th edition, Me Graw hill.
3. D Voet, *Biochemistry* by 2nd Edition, John Wiley & sons.